BW-2948A
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Quality Assurance Project Plan
Former Fort Ord, California
Volume I, Appendix A

Draft Final Addendum No. 2
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer
Extraction Well Installation

Prepared for:

U.S. Department of the Army
Fort Ord Base Realignment and Closure
4463 Gigling Road, Room 101
Seaside, CA 93955-7302

USACE Contract No: **W9123823C0026**

Task No: **2.1**

Prepared by:

Ahtna Global, LLC
9699 Blue Larkspur Lane, Suite 201
Monterey, CA 93940-6552

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Revision: **11**
Addendum No.: **2**

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Acronyms and Abbreviations

%	percent
°C	degrees Celsius
ACL	Aquifer Cleanup Level
Ahtna	Ahtna Global, LLC
APP	Accident Prevention Plan
Army	U.S. Department of the Army
bgs	below ground surface
BLL	California black legless lizard
BRAC	Base Realignment and Closure
CCAL	continuing calibration
CCRWQCB	California Regional Water Quality Control Board, Central Coast Region
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
CQCR	Contractor Quality Control Report
CQM	Construction Quality Management
CPR	cardiopulmonary resuscitation
CT	carbon tetrachloride
CTS	California tiger salamander
DQO	data quality objective
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
EW	Extraction Well
GIS	geographic information system
GWMP	groundwater monitoring program
GWTP	groundwater treatment plant
GWTS	groundwater treatment system
H&S	health and safety
HAZWOPER	Hazardous Waste Operations and Emergency Response
HDPE	high-density polyethylene
ICAL	initial calibration
IDW	investigation-derived waste
LCS	laboratory control samples
LCSD	LCS duplicate
LOD	limit of detection
LOQ	limit of quantitation

MEC	munitions and explosives of concern
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
O&M	operations and maintenance
OU2	Operable Unit 2
OUCTP	Operable Unit Carbon Tetrachloride Plume
PDB	passive diffusion bag
PE	registered Professional Engineer
pH	-log [H+]
PLC	programable logic controller
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RPD	relative percent difference
SCADA	supervisory control and data acquisition
SGS	SGS North America, Inc.
SIM	selected ion monitoring
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
VFD	variable frequency drive

1.0 Introduction

Ahtna Global, LLC (Ahtna) prepared this *Quality Assurance Project Plan, Former Fort Ord, California, Volume 1, Appendix A, Addendum No. 2, Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Extraction Well Installation* (QAPP Addendum)[1] under U.S. Army Corps of Engineers (USACE) Contract Number W9123823C0026. This QAPP Addendum describes activities to install and operate new extraction well EW-OU2-13-180 for the Operable Unit Carbon Tetrachloride Plume (OUCTP) Upper 180-Foot Aquifer remedy, as described in the *OUCTP Upper 180-Foot Aquifer Remedial Design Addendum* (Ahtna, 2024a). Specific activities include extraction well, conveyance pipe, pump, electrical, and mechanical equipment installation to be performed at the former Fort Ord (Figure 1). This work is being conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This QAPP Addendum details quality assurance (QA) and quality control (QC) procedures for extraction well installation activities.

This document is an addendum to the *Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix A, Final Revision 11, Groundwater Remedies and Monitoring at Operable Unit 2, Sites 2 and 12, and Operable Unit Carbon Tetrachloride Plume* (Groundwater QAPP Revision 11; Ahtna, 2023c) and provides additional project-specific details. Groundwater QAPP Revision 11 will be referenced as appropriate in the worksheets contained herein. Ongoing groundwater sampling and analysis for the former Fort Ord groundwater monitoring program (GWMP) are addressed in Groundwater QAPP Revision 11 (Ahtna, 2023c); therefore, this QAPP Addendum specifically discusses well installation activities and baseline sampling and only includes Optimized Uniform Federal Policy QAPP Worksheets #1 & 2, #3 & 5, #4, 7 & 8, #9, #11, #12, #14 & 16, #15, #17, #18 and #19 & 30 with additional information applicable to this project. Other worksheets and information are available in Groundwater QAPP Revision 11 (Ahtna, 2023c).

[1] This document is an addendum to Appendix A to the *Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I*. Volume I is the governing document for sampling and analysis of groundwater (Appendix A), soil (Appendix B), soil gas (Appendix C), landfill gas (Appendix D), and per- and polyfluoroalkyl substances (Appendix E). Volume II of the QAPP pertains to the former Fort Ord military munitions response program.

2.0 Worksheet #1 & 2: Title and Approval Page

Site Name/ Project Name: Former Fort Ord/Superfund Response Actions

Site Location: Former Fort Ord, California

Document Title: Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix A, Addendum No. 2, Draft, Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Extraction Well Installation

Lead Organization: U.S. Army Corps of Engineers

Preparer's Name, Organization, and Contact Info: Shaelyn Hession and Holly Dillon, Ahtna

9699 Blue Larkspur Lane, Suite 203, Monterey, CA 93940
(831) 324-3299 (831) 200-6072
hdillon@ahtna.net shession@ahtna.net

Preparation Date: March 11, 2024

Project Role	Name Organization	Signature	Date
Investigative Organization Program Manager	Derek Lieberman Ahtna		
Investigative Organization Project Manager	Holly Dillon Ahtna		
Investigative Organization Project Chemist	Eric Schmidt Ahtna		
Investigative Organization Project Engineer	TBD Ahtna		
Investigative Organization QC Manager	Steven Bennett Ahtna		
Lead Organization Technical Lead	Erin Corr USACE		
Lead Organization Project Chemist	Kyle Bayliff USACE		

Plans and reports from previous investigations relevant to this project:

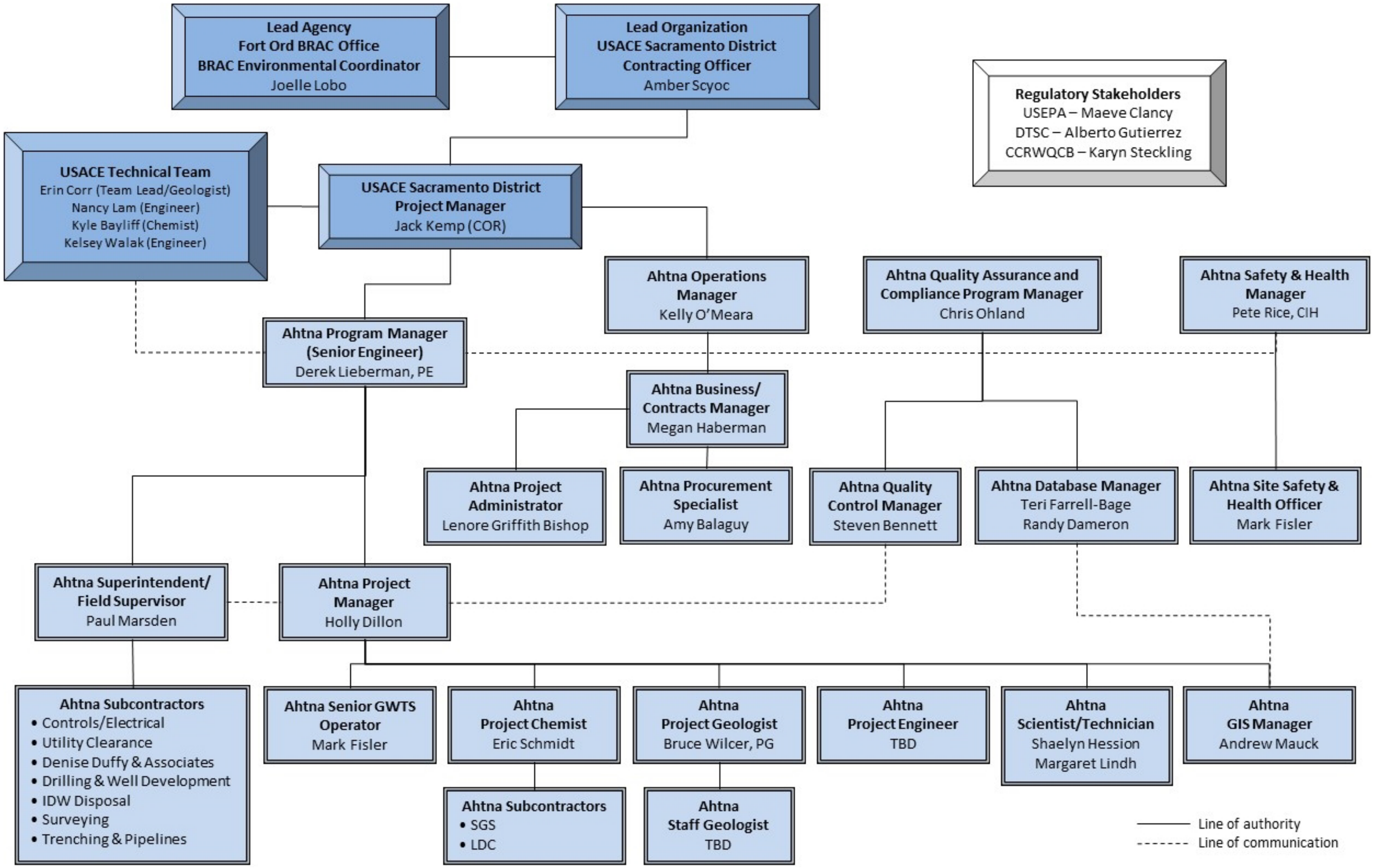
Site Name/Project Name:	Former Fort Ord/Superfund Response Actions
Site Location:	Monterey County, California
Site Number/Code:	Not Applicable
Operable Units:	OUCTP
Contractor Name:	Ahtna Global, LLC
Contract Number:	W9123823C0026
Contract Title:	Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Extraction Well, Fort Ord, Marina, California.
Work Assignment Number:	Not Applicable
Guidance used to prepare QAPP:	Uniform Federal Policy for Quality Assurance Project Plans, Optimized Worksheets, March 2012, Revision 1. Department of Defense Quality Systems Manual for Environmental Laboratories, Version 5.4, 2021
Regulatory Program:	CERCLA, as amended by the Superfund Amendment and Reauthorization Act
Approval Entities:	U.S. Environmental Protection Agency (EPA), California Department of Toxic Substance Control (DTSC), and Regional Water Quality Control Board, Central Coast Region (CCRWQCB)
Data Users:	U.S. Department of the Army (Army), USACE, EPA (and its consultant TechLaw, Inc.), DTSC, CCRWQCB, Army/USACE contractors, citizen groups, and members of the public
Organizational partners (stakeholders) and connection with lead organization:	USACE, Army (lead agency/owner), EPA (lead oversight agency), DTSC (support agency), and CCRWQCB (support agency)
The QAPP is (select one):	Generic:____ Project-Specific:_X_

Dates and titles of QAPP documents written for previous site work

Title	Approval Date
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 11	November 2023
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Draft Final Addendum No. 1, Well Installation and Decommissioning	October 2023
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 10	March 2022
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 9	November 2021
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 8	February 2021
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 7	August 2019
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 6	March 2018
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 5	June 2017
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 4	March 2016
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 3	June 2015
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 2	February 2014
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 1	December 21, 2012
Draft Final Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Groundwater Extraction and Treatment Systems at Operable Unit 2 and Sites 2 and 12; Groundwater Monitoring Program at Sites 2 and 12, Operable Unit 1, Operable Unit 2, and Operable Unit Carbon Tetrachloride Plume	May 31, 2011
Draft Final, QAPP/CDQMP Groundwater Monitoring Program, Sites 2 and 12, OU2 and OUCTP	January 20, 2010
Final Sampling and Analysis Plan, Operable Unit 2 and Sites 2 and 12 Groundwater Treatment Systems, Former Fort Ord	August 20, 2009

3.0 Worksheet #3 & 5: Project Organization and QAPP Addendum Distribution

Reporting relationships between organizations involved in the project, including the lead organization, contractors, and subcontractors.



4.0 Worksheet #4, 7 & 8: Personnel Qualifications and Sign-Off Sheet

Organization: Ahtna

Name	Project Title/ Role	Education/ Experience	Specialized Training/ Certifications[1]	Signature[2]	Date
Derek Lieberman	Program Manager/ Senior Engineer	Resume on file	First aid, CPR, MEC, PE, H&S, HAZWOPER, CQM		
Holly Dillon	Project Manager	Resume on file	First aid, CPR, MEC, H&S, HAZWOPER, CQM		
Paul Marsden	Site Superintendent	Resume on file	First aid, CPR, MEC, HAZWOPER, CQM		
Mark Fisler	SSHO/Senior GWTS Operator	Resume on file	First aid, CPR, MEC, HAZWOPER, CQM		
Eric Schmidt	Project Chemist	Resume on file	First aid, CPR, MEC, H&S, HAZWOPER, CQM		
Bruce Wilcer	Project Geologist	Resume on file	First aid, CPR, MEC, PG, H&S, HAZWOPER, CQM		
Steven Bennett	QC Manager	Resume on file	First aid, CPR, MEC, H&S, HAZWOPER, CQM		
Andrew Mauck	GIS Manager	Resume on file	Not applicable		

Notes:

[1] Specialized Training/Certifications Key:
CPR: cardiopulmonary resuscitation
CQM: Construction Quality Management
GIS: geographic information system
GWTS: groundwater treatment system
H&S: health and safety training including, but not limited to hazard communication, fire extinguisher use, defensive driving, behavior-based safety, confined spaces
HAZWOPER: 40-hour and current 8-hour annual refresher Hazardous Waste Operations and Emergency Response
MEC: munitions and explosives of concern recognition and safety training
PE: registered Professional Engineer
PG: registered Professional Geologist
SSHO: Site Safety & Health Officer
[2] Signatures indicate personnel have read and agree to implement this QAPP Addendum as written.

5.0 Worksheet #9: Project Planning Session Summary

Project Name: Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Extraction Well, Fort Ord, Marina, California.

Site Name: Former Fort Ord

Site Location: Former Fort Ord, CA

Projected Start Date: Ongoing

Project Manager: Derek Lieberman, Ahtna

Date of Session: October 20, 2023

Scoping Session Purpose: Define scope of work to be included in the QAPP Addendum

Name	Title	Affiliation	Telephone #	Email Address
Derek Lieberman	Program Manager	Ahtna	(831) 224-3327	dlieberman@ahtna.net
Eric Schmidt	Project Chemist	Ahtna	(831) 582-1348	eschmidt@ahtna.net
Holly Dillon	Project Manager	Ahtna	(831) 324-3299	hdillon@ahtna.net
Shaelyn Hession	Env. Scientist	Ahtna	(831) 200-6072	shession@ahtna.net
Margaret Lindh	Env. Scientist	Ahtna	(831) 760-1050	mlindh@ahtna.net
Andrew Mauck	GIS Manager	Ahtna	(831) 402-0727	amauck@ahtna.net
Steven Bennett	QC Manager	Ahtna	(831) 402-7886	sbennett@ahtna.net

Planning Session Summary:

Reviewed contract performance work statement and existing documents to determine QAPP Addendum requirements.

Action Items:

Based on this review, Ahtna will:

- Initiate preparation of QAPP Addendum No. 2.
- Identify changes to the Operable Unit 2 (OU2) Groundwater Treatment System (GWTS) Operations and Maintenance (O&M) Manual.

6.0 Worksheet #10: Conceptual Site Model

6.1.1 Fate and Transport Considerations

The carbon tetrachloride (CT) plume appears to have originated from a training facility referred to in 1958 as “ST-11” near what is now Lexington Court. The plume migrated through the vadose zone beneath the facility and into the groundwater of the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer; CT has not been detected in the 400-Foot Aquifer.

Hydraulic communication between the A-Aquifer and the underlying aquifers is limited to those areas west of OUCTP where the Fort Ord-Salinas Valley Aquitard (FO-SVA) clay unit pinches out, or where it was penetrated by wells without adequate sanitary seals. Two such vertical conduits were identified that resulted in the migration of CT from the A-Aquifer to the underlying Upper and Lower 180-Foot Aquifers. All identified vertical conduits have been destroyed (grouted and sealed), eliminating hydraulic communication through the FO-SVA between the A-Aquifer and the underlying aquifers. Groundwater in the Upper 180-Foot Aquifer flows to the southeast toward the apparent discontinuity in the underlying Intermediate 180-Foot Aquitard where it then recharges the Lower 180-Foot Aquifer. Groundwater in the Lower 180-Foot Aquifer primarily migrates to the east (Army, 2008).

The presence of CT in the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer (Figures 2, 3, and 4) indicates that hydraulic intercommunication occurred between what are otherwise believed to be vertically isolated aquifers. The CT plume migrated from the A-Aquifer into the Upper 180-Foot Aquifer through two known vertical conduits through the FO-SVA, creating two distinct parallel plumes. These vertical conduits (the wells with inadequate sanitary seals) were decommissioned in 1999 and 2005. The two parallel plumes commingled and continued to migrate southeastward toward discontinuity in the Intermediate 180-Foot Aquitard. Since implementation of the remedy for OUCTP in the Upper 180-Foot Aquifer in 2011, the single commingled plume has become two distinct plumes (Ahtna, 2023a). In the Upper 180-Foot Aquifer south of Reservation Road and west of Imjin Parkway, persistent CT concentrations above the Aquifer Cleanup Level (ACL) at MP-BW-46-170, which currently defines the northern extent of the northern CT plume in the Upper 180-Foot Aquifer, indicated an upgradient source of CT. However, additional monitoring and data analyses demonstrated that CT concentrations were consistently below the ACL at upgradient monitoring wells. Additionally:

- The confined Upper 180-Foot Aquifer is under pressure and groundwater is in continuous contact with the bottom of the FO-SVA in this area of OUCTP, despite seasonal variations in groundwater elevations.
- Elevated CT concentrations in groundwater have been observed at relatively shallower groundwater sampling stations near the bottom of the FO-SVA at and near MP-BW-46-170.
- Higher CT concentrations are observed at deeper stations further downgradient of MP-BW-46-170 as the CT plume migrates vertically and horizontally toward the discontinuity in the Intermediate 180-Foot Aquitard.
- CT concentration trends at MP-BW-46-170 and downgradient wells are currently declining.

These lines of evidence suggest the source of CT detected in MP-BW-46-170 is back diffusion from the bottom of the FO-SVA, as opposed to an active vertical conduit, and indicate the CT mass adsorbed to the bottom of the FO-SVA is becoming depleted (Ahtna, 2023a).

6.1.2 Potential Receptors and Exposure Pathways

Groundwater at OUCTP is not currently used for domestic household purposes by residents within the Fort Ord area. Drinking water in the Fort Ord area is provided by the Marina Coast Water District (MCWD) and is pumped from wells that are located east of the OUCTP area. These supply wells are screened in the Lower 180-Foot Aquifer or deeper aquifers. Groundwater within the OUCTP area is located in the Prohibition Zone of the Special Groundwater Protection Zone at the former Fort Ord, and Monterey County restricts installation of new supply wells in this zone. According to Monterey County Code Title 15 Section 15.08.140, a prohibition zone is an area overlying or adjacent to a contaminant plume where water well construction is prohibited and applications for water wells will not be accepted; therefore, direct contact groundwater exposure pathways for residents potentially exposed to groundwater from the OUCTP area are currently incomplete and are expected to remain so in the future. Volumes III and IV of the Basewide Remedial Investigation/Feasibility Study (HLA, 1995) provide details on the potential receptors and exposure pathways.

6.1.3 Land Use Considerations

Extraction well EW-OU2-13-180 will be located within the Fort Ord Natural Reserve (FONR). Work within the FONR requires specific consideration to minimize impact to listed and endangered plants and animals. The specific requirements for working within the FONR as part of the OUCTP remedial action are addressed in Section 10 of the main OUCTP Remedial Action Work Plan (RAWP; Shaw, 2009).

6.1.4 Hydrogeology

A general description of the hydrogeology in the area of the OUCTP is included in Section 3.0 of the OUCTP RAWP (Shaw, 2009). The hydrogeology of the overlying A-Aquifer and underlying Upper and Lower 180-Foot Aquifers is presented in more detail in Appendix A and Appendix C of the OUCTP RAWP, respectively. The design for groundwater extraction and treatment within the Upper 180-Foot Aquifer required evaluation of the lithology and hydrogeologic character of the aquifer and intercommunication between the aquifers. The geologic units directly influencing groundwater flow within the Upper 180-Foot Aquifer include the FO-SVA, the Upper 180-Foot Aquifer, the Intermediate 180-Foot Aquitard, and the Lower 180-Foot Aquifer. Cross sections were constructed to assist in the evaluation of lithology on flow within the OUCTP, specifically between the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer. The cross-section locations are presented on Figure 4. The cross sections are presented on Figure 5 (Cross Section A-A’) and Figure 6 (Cross Section B-B’).

FO-SVA

The FO-SVA separates the overlying A-Aquifer from the Upper 180-Foot Aquifer (hydrologically) over the area of the OUCTP (Figure 5 and Figure 6). The FO-SVA is a thick, dense clay unit deposited in a marine environment and contains significant organic content, occasionally in the form of peat lenses. Even though the FO-SVA represents a significant aquitard that is capable of restricting vertical flow from the A-Aquifer, intercommunication between the aquifers is indicated by the presence of CT in the Upper and Lower 180-Foot Aquifers. The CT, which originated in the A-Aquifer, migrated along with groundwater into the underlying Upper 180-Foot Aquifer as discussed in Section 6.1.1.

Upper 180-Foot Aquifer

The Upper 180-Foot Aquifer underlies the relatively impermeable FO-SVA and represents the upper lithologic sequence of the generalized 180-Foot Aquifer. The upper contact of the Upper 180-Foot Aquifer occurs at depths ranging from approximately 140 to 200 feet below ground surface (bgs) which correspond to elevations of 20 to 180 feet below mean sea level (MSL).

Depths mostly reflect variations in surface topography. The cross sections (Figure 5 and Figure 6) illustrate the uniform contact surface between the FO-SVA and the Upper 180-Foot Aquifer. The thickness of the Upper 180-Foot Aquifer ranges from 50 feet near the western extent of cross section A-A' to over 120 feet near the eastern end (Figure 5). The variations in thickness of the aquifer are generally the result of variations in the elevation of the underlying Intermediate 180-Foot Aquitard. The lithology of the Upper 180-Foot Aquifer is relatively uniform across the OUCTP area as depicted in the cross sections. The unit is composed primarily of well to poorly graded sand deposited in relatively thick beds with single depositional units comprising a large proportion of the unit's thickness in some locations. Gravel content increases toward the base of the unit, although gravel stringers are present at shallow depths locally. Silts represent a larger proportion of the section to the southeast of the suspected area of vertical communication through the Intermediate 180-Foot Aquitard (Figure 5), where the thickness of the unit increases to greater than 100 feet.

Intermediate 180-Foot Aquitard

The Intermediate 180-Foot Aquitard underlies the Upper 180-Foot Aquifer and separates it from the Lower 180-Foot Aquifer within the OUCTP area. The contact between the Upper 180-Foot Aquifer and the underlying Intermediate 180-Foot Aquitard occurs at approximately between 70 and 100 feet below MSL within the area (Figure 5 and Figure 6). This places the contact approximately between 200 and 290 feet bgs depending on ground surface elevation.

The Intermediate 180-Foot Aquitard consists of approximately 50 feet of interbedded clay and clayey sand layers, mixed occasionally with coarse gravel. The aquitard hydraulically isolates the Upper and Lower 180-Foot Aquifers, although the unit pinches out or contains more conductive lithologies in the southern portion of the OUCTP area. The pinch-out is suspected to represent an area of vertical communication between the Upper and Lower 180-Foot Aquifers. The OUCTP RI/FS (MACTEC, 2006) concluded that the Intermediate 180-Foot Aquitard pinches out locally and groundwater from the Upper 180-Foot Aquifer flows downward into the Lower 180-Foot Aquifer in these locations. The area where the CT plumes in the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer intersect (Figure 4) and the cross sections shown in Figures 5 and Figure 6 support the presence of a zone of vertical communication. The thin layers of the Intermediate 180-Foot Aquitard that are apparent in well MP-BW-42 and well MW-OU2-69-180L (below -70 feet MSL) are not present in well MP-BW-49 (Figure 5). The area depicted on Figure 5 represents the bounds of an area of vertical communication that influences (promotes) the vertical migration of groundwater. The lack of continuity of the Intermediate 180-Foot Aquitard is important to vertical groundwater flow and the migration of contaminants.

Lower 180-Foot Aquifer

The Lower 180-Foot Aquifer consists of approximately 200 feet of coarse sand and gravel and, along with the 400-Foot Aquifer, is a significant source of potable water for the former Fort Ord and City of

Marina. Remedial actions for the Lower 180-Foot Aquifer are discussed in Appendix C of the OUCTP RAWP (Shaw, 2009).

7.0 Worksheet #11: Project/Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that outline the decision-making process and specify the data required to support corrective actions. DQOs specify the level of uncertainty that will be accepted in results derived from data. The DQO process used for developing data quality criteria and performance specifications for decision-making is consistent with the *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA, 2006).

7.1 Step 1: State the Problem

CT is present in groundwater at the former Fort Ord OUCTP at concentrations above the ACL prescribed in the Record of Decision (Army, 2008). The OUCTP Upper 180-Foot Aquifer remedy is a containment approach that includes a pumping scenario for migration control of the groundwater CT plume with aboveground treatment and reinjection of treated water back into the aquifer. One extraction well, EW-OU2-09-180, pumps groundwater from the OUCTP Upper 180-Foot Aquifer to the OU2 groundwater treatment plant (GWTP), where it is treated with granular activated carbon. Operation of this well since 2011 has split the CT plume into a northern and southern portion (Ahtna, 2023a), but does not adequately contain the southern CT plume, which is within the area of the discontinuity in the Intermediate 180-Foot Aquitard, whereby CT migrates to the Lower 180-Foot Aquifer. The Lower 180-Foot Aquifer has a monitored natural attenuation remedy and is upgradient of MCWD drinking water supply wells. To prevent migration of CT above the ACL into the Lower 180-Foot Aquifer, where it could potentially impact the downgradient drinking water supply wells, a second extraction well was recommended to be installed to capture the southern CT plume in the Upper 180-Foot Aquifer (Ahtna, 2023a). A Remedial Design Addendum (Ahtna, 2024a) was prepared detailing the design for the additional extraction well, EW-OU2-13-180 and associated conveyance pipeline, system upgrades, and electrical equipment.

7.2 Step 2: Identify the Goals of the Study

The objective of the remedial action within the OUCTP Upper 180-Foot Aquifer is to minimize further impact to the Lower 180-Foot Aquifer by extracting groundwater from the downgradient edge of the CT plume in Upper 180-Foot Aquifer to remove contaminant mass and to capture the plume before it reaches the area of vertical communication through the Intermediate 180-Foot Aquitard. Installation and operation of extraction well EW-OU2-13-180 in the vicinity of monitoring wells MW-OU2-64-180 and MW-OU2-66-180 (Figure 4) will expand the current OUCTP Upper 180-Foot Aquifer remedy to capture and contain CT in the Upper 180-Foot Aquifer and prevent migration of CT above the ACL into the underlying Lower 180-Foot Aquifer.

The Fort Ord groundwater model will be updated based on data collected during hydrogeologic testing conducted following well installation and start-up activities. The model updates, including revision from a steady-state model to a transient model, will be used to optimize system operating parameters as required (e.g., an alternating pumping strategy or optimized flow rates for operating extraction wells in the Bunker Hill network).

7.3 Step 3: Identify Information Inputs

Information inputs for pipeline trench alignments include geophysical utility survey data and baseline habitat survey data.

Information inputs for the design and installation of EW-OU2-13-180 will include:

- As-built construction drawings for extraction well EW-OU2-09-180 (Attachment A).
- Boring logs for monitoring wells MW-OU2-64-180 and MW-OU2-66-180 (Attachment A).
- Geologic cross sections to determine the optimal location for extraction well EW-OU2-13-180 (Figures 4, 5, and 6).
- Groundwater capture modeling to determine the optimal operating conditions for extraction well EW-OU2-13-180 (Attachment B).
- Geologic logging of the EW-OU2-13-180 borehole via continuous core sampling to determine aquifer lithology and depth of the Intermediate 180-Foot Aquitard.

Information inputs for the selection and installation of a submersible pump in EW-OU2-13-180 will include the results of specific capacity testing conducted during well development and profile sampling to determine the aquifer zone with the highest chemical of concern (COC) concentrations following extraction well installation.

Information inputs for updating the Fort Ord groundwater model will include data collected during hydrogeologic testing conducted after well installation and start-up activities.

Information inputs for evaluating extraction well performance per the OU2 GWTS O&M Manual (Ahtna, 2022) include water quality parameter data, extraction well operational data, and hydrogeologic testing data collected after installation of the submersible pump and connection to the OU2 GWTS.

Information inputs for evaluating performance and optimization of the OUCTP remedy for the Upper 180-Foot Aquifer include:

- COC concentration data from extraction well samples collected to assess relative concentrations in the aquifer and whether ACLs have been met for COCs.
- Groundwater monitoring data and/or groundwater flow modeling results to determine whether the plume is hydraulically contained.
- Statistical analysis of COC concentration trends on a well-by-well basis.

7.4 Step 4: Define the Boundaries of the Study

The physical study boundaries for the OUCTP groundwater remedy are described in Groundwater QAPP Revision 11 (Ahtna, 2023b) and shown in Figure 1. The EW-OU2-13-180 study boundaries are shown in Figure 7. The target media of interest consists of groundwater in the OUCTP Upper 180-Foot Aquifer. Extraction well EW-OU2-13-180 will be screened across the Upper 180-Foot Aquifer. Based on historical data in the area, the Upper 180-Foot Aquifer spans approximately 150 to 220 feet bgs. This depth will be targeted for the screen interval for extraction well EW-OU2-13-180, but adjustments may be required in the field based on data collected during borehole drilling.

7.5 Step 5: Develop the Analytic Approach

The analytic approach was developed by using information inputs to support the goals of the project. These are expressed as “if-then” statements, or decision rules, that link potential results with conclusions or future actions.

1. If geophysical utility survey data or baseline habitat survey data indicate conflicts with the proposed pipeline trench alignments, then alternative pipeline routes will be evaluated.
2. If the top of the Intermediate 180-Foot Aquitard cannot be identified during borehole logging for EW-OU2-13-180, then the borehole may be within the discontinuity in the Intermediate 180-Foot Aquifer and the proposed location of the extraction well will be reevaluated.
3. If specific capacity testing during well development indicates the extraction well does not have sufficient capacity to meet project objectives, then additional well development measures may be implemented.
4. If additional well development measures do not sufficiently increase specific capacity, then historical performance of extraction well EW-OU2-09-180 may be considered for selection of the submersible pump (i.e., it is assumed well performance will improve over time with constant pumping; therefore, the pump will be sized to operate at a flowrate of 60 gallons per minute with control via a variable frequency drive [VFD] for operating a lower flowrates).
5. If baseline profile sampling of the extraction well does not indicate an aquifer zone of highest COC concentrations, then the depth of the submersible pump will be determined based on lithology and observed drawdown during well development and specific capacity testing.
6. If no aquifer response is detected in observation wells during the constant-rate portion of the hydrogeological testing, then then further well-performance testing work may be conducted to collect additional data to support system redesign.
7. If installation of the one additional extraction well provides sufficient quantity of water and yields the desired effects upon the aquifer, then no further well performance testing work will be required and the remainder of the system will be installed as specified.
8. If testing results indicate installation of the one additional extraction well cannot achieve remediation goals per the Remedial Design Addendum (Ahtna, 2024a), then further well-performance testing work may be conducted to collect additional data to support system redesign.
9. If groundwater monitoring data and COC concentration trends indicate increasing CT concentrations in the Lower 180-Foot Aquifer after continuous operation of EW-OU2-13-180, then system redesign will be evaluated.
10. If the performance of extraction well EW-OU2-13-180 declines when compared to baseline performance data per the criteria in the OU2 GWTS O&M Manual (Ahtna, 2022), then the extraction well may be rehabilitated by redevelopment or other physical or chemical treatment to address chemical encrustation, biofouling, etc.

7.6 Step 6: Specify Performance or Acceptance Criteria

The performance or acceptance criteria for the OUCTP groundwater remedy are described in Groundwater QAPP Revision 11 (Ahtna, 2023b).

7.7 Step 7: Develop the Plan for Obtaining Data

The plan for obtaining data for the OU2 GWTS and OUCTP groundwater remedy is described in Groundwater QAPP Revision 11 (Ahtna, 2023b).

Monitoring of extraction well EW-OU2-13-180 operational parameters, groundwater elevations, and OUCTP Upper 180-Foot Aquifer CT concentrations will be conducted. The data will be presented in the associated quarterly and annual reports. Data analysis will be presented in annual OUCTP reports and at associated project planning meetings. Recommendations for OU2 GWTS changes will be presented in annual OU2 reports and at associated project planning meetings.

8.0 Worksheet #12: Measurement Performance Criteria

The following sections provide measurement performance criteria for the fixed laboratory methods.

8.1 Worksheet #12a: VOCs—GWTS and GWMP, OU2 and OUCTP

Analytical Group/Method: Volatile organic compounds (VOCs) by EPA Method 8260-SIM (Selected Ion Monitoring)

Matrix: Groundwater

Both the existing extraction well EW-OU2-09-180 and the proposed extraction well EW-OU2-13-180 will be operated for the OUCTP Upper 180-Foot Aquifer remedy. However, these extraction wells are connected to the OU2 GWTS and will therefore be monitored for OU2 COCs. The performance criteria for OU2 and the OUCTP Upper 180-Foot Aquifer are included in Groundwater QAPP Revision 11 (Ahtna, 2023b).

VOCs will be analyzed during baseline sampling and long-term performance monitoring at EW-OU2-13-180.

8.2 Worksheet #12b: Dissolved Metals—OUCTP Baseline GWMP

Analytical Group: Dissolved Metals by EPA Method 6010D

Matrix: Groundwater

Analytes: Iron and manganese

Dissolved metals will be analyzed during baseline sampling only at EW-OU2-13-180.

Data Quality Indicator	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision	Field Duplicate	RPD ≤ 30 percent (%)
	LCS/LCSD and MS/MSD	RPD ≤ 20%
Accuracy / Bias	LCS and MS	Iron 87-115% Manganese 90-114%
	Method blank and field blank	The absolute values of all analytes must be < ½ LOQ or < ⅒ the amount measured in any sample or ⅒ the regulatory limit, whichever is greater.
Representativeness	Measure pH of samples upon receipt	Samples preserved to pH < 2.0
	Cooler temperature blank	> 0°C ≤ 6°C
Comparability	Historical data	Reasonableness
	LCS/LCSD and MS/MSD	Qualitative measure for field sampling procedures
Completeness	Number of samples collected out of total samples planned	≥ 95% field completeness

Data Quality Indicator	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
	Evaluation of number of unqualified results out of the total results reported[2]	≥ 90% analytical completeness
Sensitivity	LCS, ICAL, CCAL	Evidence of shift in instrument response or zero setting
	LOQ studies	Limit of quantitation

Notes:
≤: less than or equal to
≥: greater than or equal to
°C: degrees Celsius
CCAL: continuing calibration
ICAL: initial calibration
LCS/LCSD: laboratory control sample/laboratory control sample duplicate
LOQ: limit of quantitation
MS/MSD: matrix spike/matrix spike duplicate
pH: standard pH units = -log [H+]
RPD: relative percent difference

8.3 Worksheet #12c: Wet Chemistry—OUCTP Baseline GWMP

Analytical Group: Anions by EPA Method 9056A

Matrix: Groundwater

Analytes: Nitrite, nitrate, sulfate

Anions will be analyzed for during baseline sampling only at EW-OU2-13-180.

Data Quality Indicator	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Precision	Field Duplicate	RPD ≤ 30%
	Laboratory duplicates and MS/MSD	≤ 15%
Accuracy / Bias	LCS and MS	Nitrate 88-111% Nitrite 87-111% Sulfate 87-112%
	Method blank and field blank	No analytes detected > ½ LOQ or > 1⁄10 the amount measured in any sample or > 1⁄10 the regulatory limit, whichever is greater. Common contaminants must not be detected > LOQ.

[2] Results qualified as estimated due to detected quantities between the LOQ and limit of detection (LOD) will not be counted in the analytical completeness quantity assessment.

Data Quality Indicator	QC Sample or Measurement Performance Activity	Measurement Performance Criteria
Representativeness	Cooler Temperature Blank	> 0°C ≤ 6°C
Comparability	Historical data	Reasonableness
	LCS/LCSD and MS/MSD	Qualitative measure for field sampling procedures
Completeness	Number of samples collected out of total samples planned	≥ 95% field completeness
	Evaluation of number of unqualified results out of the total results reported[3]	≥ 90% analytical completeness
Sensitivity	LCS, ICAL, CCAL	Evidence of shift in instrument response or zero setting
	LOQ studies	Limit of quantitation

Notes:

≤: less than or equal to
≥: greater than or equal to
°C: degrees Celsius
CCAL: continuing calibration
ICAL: initial calibration
LCS/LCSD: laboratory control sample/laboratory control sample duplicate
LOQ: limit of quantitation
MS/MSD: matrix spike/matrix spike duplicate
RPD: relative percent difference

[3] Results qualified as estimated due to detected quantities between the LOQ and LOD will not be counted in the analytical completeness quantity assessment.

9.0 Worksheet #14 & 16: Project Tasks & Schedule

Applicable construction drawings and design specifications for the project tasks described in this Worksheet are provided in Attachment C and Attachment D, respectively. Standard operating procedures (SOPs) for the project tasks described in this Worksheet are provided in Attachment F. The sampling tasks are described in Worksheet #17 and Worksheet #18. The actual implementation of project tasks and schedule, including design and construction of EW-OU2-13-180 and associated equipment, is subject to modification based on field conditions encountered during execution of project tasks. Such modifications will be described as QAPP Addendum deviations in the Completion Report.

9.1 Pre-Field Activities

9.1.1 Notification and Access

Property owners will be notified of fieldwork activities at least three days before the start of work. Site users will be coordinated with for site access, limited access to the project site during construction, and scheduling changes.

9.1.2 Permitting

Permits for well installation will be obtained from the Monterey County Department of Health; however, no permit fees are required to be paid because the former Fort Ord is a CERCLA site.

9.1.3 Utility Clearance

A utility clearance will be performed at the proposed project locations before ground disturbing activities commence to avoid encountering underground utilities and other potential obstructions. Clearance activities include review of available utility maps, notification of utility agencies and/or utility protection organizations, as appropriate, and performing onsite surveys by a California licensed Professional Geophysicist using the appropriate geophysical equipment including, but not necessarily limited to, ground penetrating radar, electromagnetic metal detection, and radio frequency pipe location. Locations of utilities will be marked on the ground surface with indications of the assumed type of utility. Prior to initiating intrusive activities, utility location information will be reviewed, including field markings and available drawings, to ensure the excavation is a minimum of 3 feet away from a marked utility. Additionally, the extraction well boring will be hand augured (or similar method) to a depth of 5 feet below ground surface (bgs). Non-mechanical excavation methods may be required based on the documented presence of direct-buried subsurface utilities without trace wires.

9.1.4 Habitat Clearance

Prior to fieldwork activities, the Onsite Biologist will survey proposed project locations, access routes, and staging areas in the Fort Ord Natural Reserve (FONR) for Monterey gilia, Monterey spineflower, and piperia. Identified plants will be GPS-located and mapped. The baseline survey will be conducted during the peak blooming period for Monterey gilia and Monterey spineflower. The maps will be used to field-identify and mark areas that personnel may not enter, and areas that are permissible to access, stage equipment, and turn vehicles around. The Onsite Biologist will be familiar with Fort Ord Habitat Management Plan (HMP; USACE, 1997) plant and wildlife species and the requirements of the Programmatic Biological Opinion (USFWS, 2017). In accordance with the Programmatic Biological Opinion, the Onsite Biologist may conduct California tiger salamander (CTS) relocation if so authorized by the U.S. Fish and Wildlife Service (USFWS). If not so authorized, the Onsite Biologist will coordinate CTS relocation with the Fort Ord Base Realignment and Closure (BRAC) Office Biologist.

9.1.5 Traffic Control Plan

The project location is in areas with low to moderate public and/or property user traffic. Traffic control around the project site with proper safety delineators and protocol will be adhered to as described in the Accident Prevention Plan and Site Safety and Health Plan (APP/SSHP; Ahtna, 2023c).

9.2 Field Activities

The specific methods and material requirements for project activities are presented in this section. Project activities will be conducted in accordance with the APP/SSHP (Ahtna, 2023c) and the site-specific APP/SSHP Addendum (Ahtna, 2024b). Tasks will be conducted in a manner that protects the safety and health of employees and members of the public and that complies with Occupational Health and Safety Administration and USACE Health and Safety Requirements, according to the USACE Engineer Manual (EM 385-1-1; USACE, 2014).

9.2.1 Borehole Drilling and Logging

Extraction well EW-OU2-13-180 will be installed within the Upper 180-Foot Aquifer using a truck-mounted mud rotary, sonic, or air rotary casing hammer drill rig. Regardless of the drilling method, continuous sampling will be performed when the borehole is within the expected depth range of the screen interval (approximately 185 to 225 feet bgs).

The extraction well boring will be completed under the supervision of the Project Geologist, who will be responsible for borehole logging, well installation, and development. The logging will be conducted in accordance with the Unified Soil Classification System. The boring will be drilled to the top of the Intermediate 180-Foot Aquitard, which is anticipated to be approximately 225 feet bgs. Continuous core sampling will be conducted over intervals of interest as required to determine aquifer lithology and depth of the Intermediate 180-Foot Aquitard. A core sample will be collected from the bottom of the boring to confirm the clay or clayey sand common to the Intermediate 180-Foot Aquitard is encountered. The final depth of the boring and position of the well screen will be determined in the field by the Field Geologist. Drilling methods must prevent the collapse of formation material against or within 2 inches of the well screen and casing during installation and development of the well. If necessary, a temporary well casing of either iron or steel may be used to support the sides of the hole during drilling and placement of the screen, riser filter pack, and grout. Temporary casing will have an internal diameter large enough to provide a 2-inch minimum annular space entirely around the well for sufficient thickness to retain its shape and maintain a true section throughout its depth. If using drilling mud during rotary drilling operations, careful management of drilling fluids both during drilling and during well installation is required. The drilling mud physical properties (filter cake thickness, fluid viscosity, sand content, and fluid density) will be monitored during the drilling of the boring. The maintenance of proper drilling mud consistency minimizes the invasion of drilling mud into the formation and reduces well development requirements. The drilling mud parameters will be measured and documented while drilling is in progress. Ideally, the parameters should be measured at intervals of 100 feet of drilling progress. Drilling conditions may modify the practicality of measurement at these intervals. Use of additives to drilling mud installation should be avoided and will be pre-approved by the

Project Geologist. Water from a clean source may be used to assist drilling and well installation. The volume of water used will be monitored and recorded.

9.2.2 Well Construction

The well will be installed to extract groundwater from the Upper 180-Foot Aquifer to support contaminant mass removal and capture of the OUCTP within the Upper 180-Foot Aquifer to minimize further migration into the Lower 180-Foot Aquifer. The final depth of the boring and position of the well screen will be determined in the field by the Field Geologist. Well installation will comply with the *California Well Standards, Water Wells, Monitoring Wells, Cathodic Protection Wells, Bulletin 74-90 (Supplement to Bulletin 74-81)* (DWR, 1991).

Extraction well EW-OU2-13-180 will be installed such that the bottom of the extraction well is at the approximate depth of the top of the Intermediate 180-Foot Aquitard. The planned installed depth for the well is approximately 225 feet bgs.

Extraction well EW-OU2-13-180 will be screened to extend approximately 40 feet above the top of the Intermediate 180-Foot Aquitard. A piezometer tube will be installed in the same boring to the same depth and with the same screen interval as the extraction well. A diagram of a typical extraction well is provided in Attachment C, Drawing No. CU6. The materials and specifications for the completion of the extraction well are summarized in Table 1.

9.2.3 Well Construction Materials

Well construction materials will be in accordance with the *California Well Standards, Water Wells, Monitoring Wells, Cathodic Protection Wells, Bulletin 74-90 (Supplement to Bulletin 74-81)* (DWR, 1991). The material specifications for proposed extraction well EW-OU2-13-180, well instrumentation and associated piping are included in Attachment C, Attachment D, and discussed in general below.

Well Casing

Casing for the proposed well and the piezometric tube will consist of flush-joint, threaded, Schedule 80 polyvinyl chloride (PVC) manufactured per ASTM International F480. The specific casing diameter is included in Table 1 and Attachment C, Drawing No. CU6. The casing will be clean and new and joints between casing and screen will be compatible.

Well Screen

The piezometric tube screen will consist of a new Schedule 80 PVC with a slot size of 0.020 inch. The total piezometric tube screen length (approximately 40 feet) will be comprised of 10-foot sections. The extraction well screen will consist of a new, 40-foot long, Type 316 stainless steel with a slot size of 0.045 inch. Extraction well screen will be wire wrapped, with the wire welded to an internal structure. The wire will be V-shaped in the cross section so the slots between the wires widen inward to minimize clogging. A bottom cap will be installed at the bottom of each well. The specific casing diameter, slot size, and bottom cap length are summarized in Table 1 and Attachment C, Drawing No. CU6.

Centralizers

The well will be constructed with centering guides comprised of stainless steel. Mounting will be provided such that centering guides can be securely attached to the well riser. Centralizers will be positioned to ensure the well screen in the center of the borehole. One centralizer will be placed above the screen and bentonite seal, with the remaining centralizers spaced approximately every 40 feet upward for the remainder of the casing.

Filter Pack and Fine Sand

A filter pack will be placed around the well screen and will extend 5 feet above the top of the well screen. The filter pack will consist of SiLibeads® (or equivalent glass beads) or clean, washed, rounded to subrounded siliceous sand material that is free from calcareous grains or material. The gradation of the filter pack is included in Table 1. The uniformity coefficient of the filter pack material will not exceed 2.5. The well will have 3 feet of fine sand placed directly above the filter pack. The fine sand will be well-sorted and have a predominant grain size of between 0.42 millimeter and 0.074 millimeter. Filter pack and fine sand will be hard, durable, and have an average specific gravity of not less than 2.50. The sand will be visibly free of clay, dust, micaceous, and organic matter.

Well Seal and Grout

A 5-foot bentonite seal will be placed directly above the fine sand filter pack using a tremie pipe. A bentonite-cement grout seal will be used in the construction of the well and placed directly above the bentonite seal. The well will be grouted to within 36 inches of ground surface. The bentonite-cement grout will be mixed in the ratio of 5 pounds bentonite gel, one 94-pound bag of Type I Portland cement, and 7 gallons of clean, potable water. The grout will have a weight of approximately 15.3 pounds per gallon. Cement will meet requirements of ASTM C150-00. Neither additives nor borehole cuttings shall be mixed with the grout.

9.2.4 Assembly of Well

The final position of the well screen will be determined in the field by the Field Geologist. Filter pack will be placed around the well within the saturated zone. The filter pack will extend from a minimum of 1 foot beneath the bottom of the well to 5 feet above the top of the well screen. Three feet of fine sand will be placed above the filter pack. A 5-foot bentonite seal will be placed above the fine sand. The annular space from the top of bentonite seal to 36 inches bgs will consist of bentonite-cement grout. A diagram of a typical well is provided in Attachment C, Drawing No. CU6. Well construction materials will be new, clean, and in good condition. If the protective plastic shipping sleeve is damaged, the screen and casing will be decontaminated immediately prior to installation in the boring as described in Section 9.4.4. Care will be taken to ensure the pipe does not contact the ground. Joints and other accessory parts will be securely fastened prior to installation in the borehole. The screen and casing will be placed in the hole in such a manner as to avoid jarring impacts and to ensure the assembly is not damaged. Each well screen and casing will be emplaced while the temporary casing (depending on the drilling method used) is still in place in the boring. The well will be plumb, true, and centered in the hole by the use of centralizers. No centralizers will be placed on the screen sections; one will be placed above the screen and bentonite seal, with the remaining centralizers spaced approximately every 40 feet upward for the remainder of the casing. Excessive misalignment or binding will be corrected before placing the filter pack.

Filter Pack Placement

To prevent compression of the well screen, the casing and screen will be suspended in the borehole until the filter pack is placed. The filter pack will be tremied into place, from the bottom of the borehole up, in such a manner as to ensure uniform placement around the screen. Temporary casing will be withdrawn from the boring as the filter pack is placed in a manner that will not cause the well to be displaced. During placement of the filter pack, frequent measurement of the top of the filter pack will be made to assure the bottom of the drive casing is not higher than 2 feet below the top of the filter pack. Water added to the filter pack during the tremie operation will be from a known clean source. The volume of water added will be monitored and recorded. Filter pack material will be protected from contamination prior to placement by either storing it in plastic-lined bags or in a location protected from the weather and contamination on plastic sheeting. Filter pack materials will be transported to the site in a manner that prevents contamination by other soils, oil and grease, and other chemicals.

Bentonite Seal and Grout Placement

The well will have 3 feet of fine sand placed directly above the filter pack and a bentonite seal placed directly above the fine sand. The fine sand and bentonite seal are intended to keep the bentonite cement grout from infiltrating into the filter pack. Prior to placement of the seal, soundings will be conducted to verify the filter pack extends 5 feet above the top of well screen elevation. If it does not, sufficient filter pack material will be added to bring the pack to the specified level for the given well design. The bentonite seal will consist of ⅜-inch pellets or slurry, which will be added via a tremie pipe. The well will be grouted to 36 inches bgs with a bentonite-cement grout. The grout will be placed by tremie pipe submerged in grout after initial placement of grout. The tremie pipe may be raised as the grout is placed as long as the discharge end remains submerged in grout. Additional grout will be added from the surface to maintain the level of grout, as specified, as settlement occurs.

Additional information regarding well construction is in Attachment D, Section 33 51 39.

9.2.5 Well Surface Completion – Well Vault and Vault Lid

The extraction well surface completion will include an underground concrete vault to allow for wellhead access and extraction pipe and electrical connections below grade. The interior dimensions of the vault will be approximately 8 feet long by 6 feet wide by 4 feet deep. The vault may be pre-cast or constructed on site. The vault walls and floor will be a minimum 8 inches thick. The vault will have access holes for the wellhead, extraction piping, and electrical conduits. The vault will also include a 36-inch diameter sump that is 18 inches deep and is grouted to the bottom. See Drawing CU7, Drawing CU8, and Drawing CU9 in Attachment C for specifications.

Following well installation, the area surrounding the extraction well will be excavated to allow for the construction of the vault and sump. The bottom of the excavation will be covered by a geotextile fabric. Additional information regarding geotextiles is in Attachment D, Section 31 05 19.13. An 8-inch layer of class II aggregate base will be placed over the fabric and compacted to 95 percent of maximum compaction. The vault will be constructed of concrete composed of Type I or II Portland cement conforming to ASTM C150; coarse and fine aggregate conforming to ASTM C33; and clean, potable water free of deleterious amounts of oils, acids, alkalis, salts, and organic material. Rebar will be sized and placed within the vault walls and floor to provide H-10 load rating. A construction joint will be installed in the vault between the walls and floor to resist hydrostatic pressure. The top of the vault will be completed to just above the existing grade elevation and accessible through a traffic rated, lockable lid. Additional information regarding cast-in-place concrete is in Attachment D, Section 03 30 53.

A vault lid constructed of corrosion-resistant aluminum will be attached to the concrete vault. The vault lid will be spring-loaded and hinged with a recessed lock box. The hinged lid will have a range of motion from being locked closed to 90 degrees open or greater. Two lids are required to meet the 60 pounds of maximum force to open. The lid will be attached to the well vault by type 303 stainless steel mounting bolts and nuts. Lid frames, mounting hardware, washers, and other fittings will be composed of type 304 or type 316 stainless steel. Anchor bolts will be stainless steel type 304 and penetrate the concrete a minimum of 4 inches on the vertical axis and at least 3 inches on the horizontal axis.

Vault lids will have a rainwater collection tray. When the lid is closed, falling rain will drain away from the vault. A concrete apron will be placed around the vault lid to support the lid and provide protection. The apron will extend a minimum of 12 inches in each horizontal direction, with the surface sloped away from the lid. Typical vault surface completion details are included in Attachment C, Drawing No. CU8.

9.2.6 Groundwater Extraction Equipment

A submersible pump will be installed in extraction well EW-OU2-13-180 to pump groundwater to the OU2 GWTP. The specific pump size will be determined by specific capacity testing conducted during well development following extraction well installation. The pump will be installed in the extraction well at a depth near the bottom of the screened interval to maximize the groundwater recovery from the well. The pump will be suspended by stainless steel type 304 downhole pipe attached to the well cap, which rests on the top of the extraction well casing (Attachment C, Drawing No. CU7). A shroud constructed from PVC will be installed over the pump and motor to direct water flow over the motor to the impeller opening. Power cables with a water-proof termination fitting will be installed from the pump motor to the electrical panel in the well vault.

Piping at the wellhead will be Schedule 80 PVC and will include a globe valve to control the flow from the well and a check valve and gate valve to isolate the well from other wells connected to the header piping. Attachment C, Drawing No. CU7 includes an extraction well vault plan. Because of the potential pressure induced by the well pump, the globe valve and components between the well cap and globe valve will be rated for a minimum of 250 pounds per square inch (psi). Components after the globe valve within the well vault will be rated to 160 psi. A sample port will also be installed at the wellhead for system monitoring. A digital output PVC float switch will be installed in the well vault to indicate a high water level in the vault as a result of a pipeline leak.

9.2.7 Electrical Power and Control Installation

An existing 200-amp, 3-phase, 480Y/277-volt commercial meter service drop is located north of the intersection of Abrams Drive and Bunker Hill Drive. The service drop feeds a Four-Well Power and Control Panel located next to extraction well EW-OU2-08-180. Power is fed through #4/0 wire between the drop and the panel. The panel provides a secure location for both the 480-volt power distribution and low voltage instrumentation control. The panel contains two circuit breakers/motor starters and a programable logic controller (PLC). The panel also contains space for two additional circuit breakers/motor starters. The electrical site plan and wiring diagram are shown in Attachment C, Drawings S7, S8, S9, ELD01, ELD02, and ELD03. The following sections describe how power and control wiring will be distributed from the existing Four-Well Power and Control Panel to new extraction well EW-OU2-13-180.

Electrical Power

Electrical power will be distributed from the Four-Well Power and Control Panel to new extraction well EW-OU2-13-180 through PVC conduit installed between the panel and the tie-in vault near existing extraction well EW-OU2-09-180 and PVC conduit buried adjacent to the new extraction conveyance pipeline between the tie-in vault and EW-OU2-13-180. The wire and conduit will be sized based on the final extraction well pump size in accordance with industry standards and the pump manufacturer's requirements. Pull boxes will be spaced no more than 200 feet apart along the length of the new conduit. Power will be terminated in the extraction well vault in a National Electric Manufacturers Association 4X panel with a lockable disconnect switch. The switch will be connected to a motor-run VFD that will be connected to the downhole extraction pump through the motor power cable. The disconnect and VFD will be sized based on the final extraction pump size in accordance with industry standards. The power in the extraction well vault will be grounded in accordance with National Electric Code requirements. Additional information regarding electrical power is in Attachment D, Sections 26 05 00.00 40, 26 05 26.00 40, and 26 28 00.00 10. Additional information regarding VFDs is in Attachment D, Section 26 29 23.

Instrumentation

Instrumentation within the well vault will include a flow-indicator totalizer, pressure switch with gauge, downhole pressure transducer, level switch (leak detection), and VFD. The flow indicator totalizer will be installed at the wellhead to monitor instantaneous flowrate and total gallons extracted from the well. The flowmeter will be a Rosemount magnetic style water meter with 1.5 percent accuracy and a 4- to 20-milliamp output.

A digital pressure switch will also be installed to monitor the pump pressure and ensure safe operation of the extraction system. The switch will be adjustable and provide a digital output. The switch will have a pressure range of 0 to 200 psi. The pressure switch will be installed downstream of a pulsation dampener to reduce false high-pressure readings caused by pipeline pressure surges.

A pressure transducer will be installed in the extraction well piezometric tube at a depth near the bottom of the extraction pump to measure the water level within the extraction well and control the operation of the pump to prevent the pump from running dry and cavitating. The pressure transducer will be welded titanium with a sealed gauge, 0 to 60 psi gauge span, ±0.25 percent accuracy, with a 4- to 20-milliamp output.

A digital output stainless PVC float switch will be installed within the well vault to allow for detection of leaks within the well vault and extraction conveyance pipeline that would drain into the vault sump.

Instrumentation wiring will be distributed from the Four-Well Power and Control Panel to new extraction well EW-OU2-13-180 through electrical PVC conduit installed between the panel and the tie-in vault near existing extraction well EW-OU2-09-180 and PVC conduit buried adjacent to the new extraction conveyance pipeline between the tie-in vault and EW-OU2-13-180. The instrumentation conduit will be separate from the power distribution conduit to minimize interference. Pull boxes will be spaced no more than 200 feet apart along the length of the new conduit. The instrumentation wiring will be terminated at the upgraded PLC within the panel. Additional information regarding instrumentation is in Attachment C.

Supervisory Control and Data Acquisition/Instrumentation Interface

Information to operate the extraction well pump will be locally programmed into both the upgraded Bunker Hill PLC and within the Four-Well Power and Control Panel near EW-OU2-08-180. A separate effort will be required to integrate these signals into the existing supervisory control and data acquisition (SCADA) control system located at the OU2 GWTP. The anticipated effort includes adding an additional well to the existing SCADA monitoring screens and to verify data are being received, logged, and properly interpreted. Additional information regarding process control is in Attachment C.

9.2.8 Excavation Conveyance Pipeline

The conveyance piping from the well vault will connect to a main header leading to the OU2 GWTP near extraction well EW-OU2-09-180 (Figure 7). The alignment will be field verified to ensure that there is sufficient clearance for the excavation work to be completed. The pipeline routes will be marked for belowground utilities and pipelines in accordance with the OUCTP RAWP (Shaw, 2009). The following sections provide the extraction conveyance pipeline construction details.

Trenching

After clearing and grubbing (Attachment D, Section 31 11 00), the trench excavation will be performed using a suitable backhoe or excavator. The excavation will follow the pipe alignment and survey stakes. The side slopes will be laid back at the angle of repose of the in situ material if native soil lacks the physical characteristics to support the trench walls. Deeper excavations, if required, will be benched, laid back, or shored. The excavated soil will be placed adjacent to the trench at a minimum distance of 2 feet from the edge to minimize trench wall collapse.

Based on previous trenching in the area, native soil at the bottom of the trench is assumed to be adequate for bedding. If it is not, clean soil will be placed in the trench bottom and on the sides of the installed pipe. Appropriately spaced grade control stakes will be installed along the trench alignment. Grade stakes will be clearly marked as to horizontal offset of alignment, well locations, planned bottom of trench, planned pipe connections, and pipe invert elevations. During construction, grades will be checked to confirm that specified locations and elevations have been achieved. Grade checking will be confirmed by the surveyor under direction of contractor QC personnel.

Trench backfilling will commence upon completion of conveyance pipeline placement and testing. A partial backfill to restrain the pipeline is allowed prior to the pressure testing. Backfill sand will be placed on both sides of each pipe, the full width of the trench, and up to the spring line. Vibratory plate compactors or water jetting may be used to compact the sand and ensure that the pipe is adequately supported. Fill will then be placed in loose lifts not to exceed 24 inches. Leak detection and electrical conduits will be placed as appropriate. Filling and compaction will continue until the trench is brought up to final grade. A colored, inscribed, metal-impregnated warning tape will be placed at approximately 1 foot below finish grade. Surface restoration will be minimized within the FONR to minimize impact to existing plant species. Additional information regarding trenching is in Attachment D, Section 31 00 00.

Conveyance Pipeline

Following the gate valve in the well vault, the piping will transition from Schedule 80 PVC to double-contained high-density polyethylene (HDPE). The extraction conveyance pipeline will include approximately 841 feet of 6-inch by 10-inch double-contained piping. Figure 7 shows the proposed alignment of the pipeline. Pipe lengths may be adjusted based on field routing to avoid utilities or other obstructions. The specified sizes of pipe, tees, elbows, and necessary vents and drains will be installed within the trench and connected per manufacturers' recommendations. Power and control wiring conduit will also be installed within the extraction pipeline trench. Typical layout of piping and conduit within a trench is shown in Figure 8.

High and Low Points

The profile for the proposed pipeline and the low and high points are shown in Attachment C, Drawing No. CU5. It is anticipated that the tie-in at the existing conveyance pipeline is the only high point in the proposed pipeline and the existing conveyance pipeline includes sufficient high point vents. A low-point drain will be installed on the conveyance pipeline to allow water to be drained from the pipeline in case of leaks or for maintenance. The low-point drain will be placed inside a precast concrete vault. The vault will be located in nontraffic areas with the top placed 6 inches above ground to reduce stormwater drainage into the vaults. Covers will be incidental-traffic, H-10 load rated. Covers will be corrosion resistant and installed with a secure locking mechanism. Attachment C, Drawing No. CU8 presents the low-point drain details.

Isolation Valve

An isolation valve will be installed in the HDPE pipeline just before the connection to the existing extraction conveyance pipeline. This isolation valve serves to isolate the pipeline to proposed extraction well EW-OU2-13-180. The isolation valve will be placed inside a precast concrete vault. The vault will be located in nontraffic areas with the top placed 6 inches above ground to reduce stormwater drainage into the vaults. Covers will be incidental-traffic, H-10 load rated. Covers will be corrosion resistant and installed with a secure locking mechanism. Attachment C, Drawing No. CU9 presents the vault details.

Pressure Testing

The double-contained pipe will be visually checked prior to pressure testing. Carrier pipe will be hydrostatically pressure tested with potable water in sections prior to backfilling the trench. The annular space of the secondary contained pipe will be pressure tested with air in sections prior to backfilling the trench. Welds, fittings, and flanges will be left uncovered during pressure testing. Test pressure and procedures will follow the HDPE pipe manufacturers' instructions, as modified by design limitations of the ancillary connected components and following the recommendations of the field engineer.

Alignment Marking

A licensed surveyor will survey, prior to backfill, pipeline routes and tops of well vaults. As-built drawings locating the actual pipe alignments and construction details relative to permanent survey monuments will be developed. Horizontal and vertical control will be surveyed to ±0.1 foot.

9.3 Post-Field Activities

The specific methods for well development, surveying, follow-up habitat monitoring, sampling, and reporting are presented in this section.

9.3.1 Well Development

Within one week after the well has been constructed, but no sooner than 48 hours after grouting is completed, the well will be developed using a bailer, vented surge block, and submersible pump. The total depth of the well and the depth to water measurements will be used to calculate the volume of water in the well casing. The well will be developed by alternately bailing and surging with a vented surge block. Care shall be taken so as not to dislodge the end plug or to disturb the well casing and screen. The well will be bailed prior to surging to remove debris.

Following bailing, the well screen will be carefully surged for a minimum of 15 minutes. During well surging, the vented surge plug will be placed at different depths within the screened portion of the well to expedite well development. If this development technique does not produce satisfactory results within one hour, then pumping the well with a submersible pump may be conducted. Care will be taken when developing with a submersible pump so as not to over pump the well and plug the sand pack. Additives and dispersing agents will not be used during well development without express permission of the Project Geologist.

During development, the Field Geologist will monitor well development water for turbidity, pH, temperature, and specific conductance using a hand-held instrument (Horiba U-10 or equivalent). For each casing volume of water removed, measured water quality parameters (temperature, specific conductance, pH, and turbidity) will be recorded on the well development log. Water quality parameters will be measured in the following units:

- Temperature — degrees Celsius (°C)
- Specific conductance — micromhos per centimeter (µmhos/cm)
- pH — standard pH units = -log [H+]
- Turbidity — Nephelometric Turbidity Units

A minimum of ten (10) well casing volumes of water plus an additional 1,000 gallons of groundwater will be removed from the well; however, development should continue until water quality parameters have stabilized or the Field Geologist determines that additional development is not warranted. Stabilization is defined as three successive readings as follows:

- pH has changed less than 0.1 pH units
- Temperature has changed 1°C or less and is approximately equal to ambient groundwater temperature
- Conductivity has changed less than 10 percent
- Development water registers less than 5 Nephelometric Turbidity Units.

Specific capacity testing will be conducted during well development to evaluate the production capacity of the well. Specific capacity is a term used to express the productivity of a well, and is defined as Q/s, where Q is the discharge rate and s is the drawdown in the well. The observed drawdown in the well is a function of aquifer and well loss; therefore, Q/s is a term incorporating both aquifer and well performance. Water levels and flowrates will be measured during the process of pumping the well. If specific capacity testing indicates the well does not have sufficient capacity to meet project objectives, additional well development measures may be implemented.

9.3.2 Extraction Well Operations

The following sections provide guidance for checkout and startup of extraction well EW-OU2-13-180, initial baseline groundwater sampling, and specific requirements for long-term system operations, maintenance, and monitoring relative to this well.

System Checkout and Startup

Startup of extraction well EW-OU2-13-180 will include inspections of the mechanical and electrical equipment to ensure proper installation and operation. Hydrogeologic testing will also be conducted to evaluate recovery and OUCTP capture from the new well operating alone and in conjunction with the OU2 GWTS.

Mechanical and Electrical Completion Check

A mechanical and electrical completion check will be performed to verify the correct installation of the equipment. Installation of all components need not be completed for this inspection to commence. Mechanically moving devices will be individually inspected prior to and immediately following installation. This initial inspection includes a visual check of the moving parts to confirm whether the parts are free to operate as specified after installation.

During the final mechanical check, a visual inspection of the entire system against the construction drawings will be made to confirm that equipment and pipelines are in their proper locations and are appropriately connected, bolts and fittings have been tightened, and supports have been secured to support the intended weight. The mechanical completion checklist for the initial shakedown/startup will be prepared after all mechanical items have been installed.

During the electrical check, electrical equipment and wiring will be visually checked against construction drawings to ensure proper installation and connections. Wiring will be tested with a megohmmeter to ensure the wiring is intact and properly insulated. Instrumentation will be calibrated in accordance with the manufacturers' recommendations and tested to verify proper operation. After the installation of the power system, an operating test will be performed to assure proper rotation of the extraction pump. Following the installation of the control system, the GWTP operator will perform tests to ensure proper operating conditions. Alarms and automatic shutdowns will be tested by forcing a failed condition. The SCADA system will integrate the signals from the instruments installed within new extraction well EW-OU2-13-180 and associated extraction conveyance pipeline to the upgraded Bunker Hill PLC.

Hydrogeologic Testing

Hydrogeologic testing to determine specific capacity and transmissivity will be conducted to evaluate recovery and CT plume capture by new extraction well EW-OU2-13-180 operating alone and in conjunction with the OU2 GWTS. Testing will be conducted after construction of EW-OU2-13-180 and the associated conveyance pipeline are complete. Therefore, the pump used for testing will be the one specified and installed in EW-OU2-13-180 based on the results of pump testing during well development, and groundwater extracted from EW-OU2-13-180 during testing will be discharged into the pipeline to the OU2 GWTP. In this configuration, "operating alone" means EW-OU2-13-180 will be the only well operating in the Eastern Main – all extraction wells in the Abrams/Imjin Network, Bunker Hill Network, and GWTP Network will be offline to the extent practicable, except that a minimum of 600 gallons per minute of extracted groundwater must be processed through the OU2 GWTP for operational stability. "Operating in conjunction with the OU2 GWTS" means all extraction well networks will be online and operated at flow rates within GWTS capacities.

Baseline Trend

Baseline data provides a basis for correcting the test data to account for on-going regional water level changes. Prior to beginning the test, a baseline trend in the water levels in the extraction well and observation wells will be established, with the period of observation being at least one week before the start of testing.

Step-Drawdown Testing

Ahtna will perform a step-drawdown test to establish the optimum constant-rate pumping test flowrate from EW-OU2-13-180. Immediately before pumping begins, the static water level in the extraction well will be recorded. The step-drawdown test will be conducted for a period of 8 to 12 hours with pumping at three or more steps of increasing flow rate, and each flow rate maintained for approximately 2 to 4 hours. The flow rates during step-drawdown testing will be set and adjusted during the test using the VFD and ball valves at the wellhead to prevent average variation in flow rate of more than plus or minus 5 percent. Flow will be measured throughout the duration of the test with a flowmeter installed inline at the wellhead (Rosemount magnetic-style water meter with 1.5 percent accuracy and a 4- to 20-milliamp output or equivalent), with flow data recorded continuously via the SCADA system. Depths to water will be measured with a pressure transducer installed in the extraction well piezometric tube at a depth near the bottom of the submersible pump. The pressure transducer will be welded titanium with a sealed gauge, 0 to 60 psi gauge span, ±0.25 percent accuracy, with a 4- to 20-milliamp output. Continuous water level measurements from the pressure transducer will be recorded in the SCADA system. The extraction well will be allowed to recover between the step-drawdown testing and subsequent constant-rate test.

Constant-Rate Testing

Ahtna will conduct water level and flowrate monitoring of the extraction well and two nearest monitoring wells (likely MW-OU2-64-180, screened in the Upper 180-Foot Aquifer, and MW-OU2-66-180, screened in the Lower 180-Foot Aquifer). Pumping test monitoring equipment will be secured inside the test well vaults and/or monuments during nighttime hours of the test.

Immediately before pumping begins, the static water level in the extraction well and monitoring wells will be recorded. The extraction well will be tested for at least 24 hours at a flowrate determined from the results of the step-drawdown test. Adjustments will be made, if necessary, during the test to maintain the constant flowrate using the VFD and ball valves at the wellhead to prevent average variation in flow rate of more than plus or minus 5 percent. Flow will be measured throughout the duration of the test with a flowmeter installed inline at the wellhead (Rosemount magnetic-style water meter with 1.5 percent accuracy and a 4- to 20-milliamp output or equivalent), with flow data recorded continuously via the SCADA system. Depths to water at the extraction well will be measured with a pressure transducer installed in the extraction well piezometric tube at a depth near the bottom of the submersible pump. The pressure transducer will be welded titanium with a sealed gauge, 0 to 60 psi gauge span, ±0.25 percent accuracy, with a 4- to 20-milliamp output. Continuous water level measurements from the pressure transducer will be recorded in the SCADA system.

Observation wells are expected to be the two nearest existing monitoring wells that will provide the best opportunity to measure aquifer response to pumping and the boundary effects during the pumping test. Depths to water at the two nearest monitoring wells will be measured using an electric water level meter (Heron Dipper T2 or equivalent) or pressure transducers and data loggers (In-Situ Level Troll or equivalent). Depth to water will be recorded prior to the start of pumping, during daytime hours of the pumping test, and during well recovery at approximately 10- to 60-minute intervals in the associated monitoring wells.

To evaluate whether pumping from the Upper 180-Foot Aquifer near the discontinuity in the Intermediate 180-Foot Aquitard will affect the Lower 180-Foot Aquifer, manual monitoring of the depth to water will be recorded prior to the start of pumping, during daytime hours of the pumping test, and during well recovery at approximately 10- to 60-minute intervals in the closest monitoring well screened in the Lower 180-Foot Aquifer. Manually measured data will be recorded on Ahtna Form SWE-FFRM 406.00 (Attachment E), or an approved equivalent.

The extraction well and wells within at least 500 feet of any designated monitoring or extraction wells will not be pumped for a minimum of 24 hours prior to testing, during the test, and until completion of recovery monitoring. The wells will be confirmed to be at static water level prior to testing, which will be interpreted as the water level upon first arrival at the well. Water levels will be monitored for 24 hours after termination of pumping to monitor groundwater level recovery within the extraction well and monitoring wells. Recovery measurements will be made in the same manner as the drawdown measurements.

Interpretation and Reporting

Pumping test data will be plotted on semi-log graphs (unless another pump test interpretation is indicated) to estimate transmissivity[4] and specific capacity. Recovery data will be used to project residual drawdown. The results of the step-drawdown and constant-rate pumping tests, including data presented in tabular and graphical formats and complete calculations, will be presented in the Completion Report. Data from the hydrogeologic testing will be provided for incorporation into the groundwater model.

9.3.3 Groundwater Elevation Monitoring

A minimum of 48 hours after well construction and development activities are completed, the groundwater elevation will be measured at the new well using a hand-held measuring device and recorded. Data from the groundwater elevation monitoring will be provided for incorporation into the groundwater model.

9.3.4 Surveying

Following well installation, the well will be surveyed by a professional California-licensed land surveyor for northing and easting coordinates and elevation with respect to MSL in compliance with established protocol. Surveying will be conducted using North American 1983 Datum, California State Plane Zone 4 horizontal and National Geodetic Vertical Datum 1929.

[4] Transmissivity, T, is defined as the rate of flow of water through a vertical strip of aquifer one unit wide extending the full saturated thickness of the aquifer under a unit hydraulic gradient. It is equal to hydraulic conductivity times aquifer saturated thickness. Dimensions are L^2/t.

9.3.5 Systems Operations and Maintenance

New extraction well EW-OU2-13-180 will be incorporated into and operated as part of the OU2 GWTS. The OU2 GWTS is currently operated in accordance with the OU2 GWTS O&M Manual (Ahtna, 2022), which provides the specific requirements for startup of the GWTS after major modifications and general guidance for system operations, maintenance, and monitoring. The OU2 GWTS O&M Manual will be revised following system construction to incorporate necessary changes related to the new equipment, including revisions to system control logic, changes to periodic checklists, and changes to as-built drawings. Future system optimization will consider operation of extraction well EW-OU2-13-180 for capture of the OUCTP in the Upper 180-Foot Aquifer.

9.3.6 Groundwater Monitoring Program

Baseline sampling will be conducted after the development of the extraction well and during the next scheduled quarterly sampling event associated with the GWMP following well development. Accordingly, QC samples will be collected and samples will be analyzed by EPA Method 8260-SIM for volatile organic analysis following sampling and laboratory analytical protocols identified in Groundwater QAPP Revision 11 (Ahtna, 2023b). Baseline sampling will be conducted in two phases: 1) passive diffusion bags (PDBs) for profiling the water column prior to pump installation; and 2) sample collection from the sample port in the well vault with the pump operating. Phase 1 baseline sampling includes installation of a weighted rope with identified stations at approximately five-foot intervals in the screened well zone. PDBs will be placed at each saturated station for at least two weeks prior to sampling. Phase 2 of the baseline sampling will occur following the placement of the submersible pump. Subsequent sampling for performance monitoring and long-term monitoring will be conducted as part of the Fort Ord Basewide quarterly GWMP and subject to Groundwater QAPP decision rules to determine sampling frequency.

9.3.7 Follow-Up Habitat Monitoring

The Onsite Biologist will conduct three years of annual follow-up habitat monitoring in the areas of the FONR disturbed during well installation field activities. Habitat monitoring will be conducted in accordance with the HMP (USACE, 1997) and the Programmatic Biological Opinion (USFWS, 2017). Follow-up surveys will be conducted during the peak blooming period for the species being monitored (Monterey gilia and Monterey spineflower). Each year for the three-year follow-up habitat monitoring period an evaluation report will be prepared and provided to the Fort Ord BRAC Office Biologist detailing updated special-status plant species populations and document impacts during the well installation.

9.3.8 Deliverables and Reporting

Field daily reports will be presented weekly in Contractor Quality Control Reports (CQCRs) during field activities.

Electronic data deliverables will be provided by the laboratory performing analyses in accordance with Groundwater QAPP Revision 11 (Ahtna, 2023b). Preliminary and validated sample analytical results will be presented at project meetings and in the appropriate quarterly and annual reports.

A Completion Report will be prepared following completion of field activities. The Completion Report will document work associated with the construction of the new OUCTP extraction well and tie-in to the existing OU2 GWTS, and will present geologic logs, well completion diagrams, well development records, and sample analytical results.

Results of the follow-up habitat monitoring of the special-status plant species in impacted areas will be reported annually for three years after construction is completed.

9.4 Investigation Derived Waste Management and Equipment Decontamination

Liquid, solid, personal protective equipment, and miscellaneous waste will be managed per the applicable provisions in SOP FSOP-802.00 (Attachment F).

9.4.1 Investigation-Derived Waste – Liquid

Liquid investigation-derived waste (IDW), including groundwater purged during sampling or well development and rinsate water from equipment decontamination, will be contained in labeled drums or tanks and will be treated at the OU2 GWTP or the Sites 2 and 12 GWTP. The OU2 and Sites 2 and 12 groundwater remedies consist of groundwater pump and treatment systems designed to remediate water containing COCs by pumping it through liquid-phase granular activated carbon. Accumulated sediment from well development activities will be disposed of at the Fort Ord Landfills.

9.4.2 Investigation-Derived Waste – Soil

Soil IDW, including soil generated from drilling, will be contained in drums or bins onsite and will be characterized and disposed of as described below. Two representative samples will be collected from the borehole cuttings and analyzed for OU2 groundwater COCs by EPA Method 8260D, as listed in Groundwater QAPP Revision 11 (Ahtna, 2023b), to evaluate for the presence or absence of other sources of contamination in the vadose zone in the area of the new well that could affect groundwater. Analytical results will be compared to EPA Regional Screening Levels (RSLs) for industrial soil. If COCs are not detected or are detected at concentrations less than or equal to RSLs, then the soil cuttings or cores may be disposed of near the borehole. Otherwise, soil IDW will be disposed of at the Fort Ord Landfills, consistent with the *Record of Decision, Basewide Remedial Investigation Sites* (Army, 1997b) in conjunction with the *Explanation of Significant Differences, Consolidation of Remediation Waste in a Corrective Action Management Unit (CAMU), Operable Unit 2 Landfill* (Army, 1997a) and the *Explanation of Significant Differences, No Further Action for Munitions and Explosives of Concern, Landfill Gas Control, Reuse of Treated Groundwater, Designation of Corrective Action Management Unit (CAMU) Requirements as Applicable or Relevant and Appropriate Requirements (ARARs), Operable Unit 2, Fort Ord Landfills* (Army, 2006), which designates CAMU regulations as ARARs for the Fort Ord Landfills (Title 22 California Code of Regulations, Section 66264.552).

9.4.3 Investigation-Derived Waste – Solid Waste

Solid non-hazardous waste, such as disposable personal protective equipment and non-reusable sampling equipment, will be disposed of in a waste receptacle located at the OU2 GWTP at 11000 Engineering Equipment Road, Marina, California.

9.4.4 Equipment Decontamination and Support Facilities

Any equipment brought onsite will be decontaminated in accordance with the SOP (Attachment F) and any requirements set forth in the Habitat Checklist. Drilling, sampling, and support equipment brought to the site will be in operable condition and free of leaks in the hydraulic, lubrication, fuel, and other fluid systems. Drilling and sampling equipment and tools will be cleaned and decontaminated prior to rig mobilization to the well location and will be maintained in a clean condition throughout drilling and sampling activities.

Downhole drilling and development equipment will be: (1) cleaned of caked drill cuttings, soil, or other material using a brush; (2) steam-cleaned using a hot water high-pressure washer; and (3) rinsed with potable water prior to its use downhole. Decontaminated equipment will be kept off the ground by storing on clean metal racks (not wooden pallets) and/or wrapped in plastic.

Support facilities include lockable containers, chemical toilets, portable containment tanks and bins with lids. Lockable support facilities will be secured when project personnel are not on site. It is anticipated most of the support facilities will be located in the vicinity of the Ahtna field offices adjacent to the OU2 GWTP.

9.5 Environmental Protection Plan

Environmental protection is defined as maintaining the environment in its natural state, to the extent possible, during and after fieldwork activities and returning the disturbed site to conditions similar to those present prior to these activities. Environmental protection will consist of protecting air, water, land, and biological resources.

9.5.1 Air Resources Protection

Fieldwork activities will be conducted to minimize the release of airborne particulates within and outside of the boundaries of the site. Dust and particulates will be controlled in accordance with the APP/SSHP (Ahtna, 2023c) to minimize contaminate dispersion and to protect human health and the environment. The use of water to control dust will be minimized to avoid impact to natural resources. Visual air monitoring will be conducted to verify the effectiveness of the program.

9.5.2 Land Resources Protection

Fieldwork within the FONR will be coordinated with the USACE Technical Lead, Onsite Biologist, Fort Ord BRAC Office Biologist, and the University of California, which manages the area, to minimize impact to natural resources and ongoing research projects. Coordination will include:

- Scheduling FONR fieldwork to be conducted between June 1 and October 31 (i.e., outside the primary growing season for rare plants) as determined by the Onsite Biologist and approved by University of California and the BRAC Office Biologist, to avoid the flowering periods of special-status species.
- Maintaining site security.
- Defining acceptable and unacceptable work areas, access routes, and turnaround and staging locations in the Habitat Checklist (Attachment G).
- Ensuring implementation of the conservation measures identified in the HMP (USACE, 1997) and Programmatic Biological Opinion (USFWS, 2017).

Prior to intrusive activities within the FONR, the Onsite Biologist will review existing habitat surveys to determine the quantity and specific location of threatened or endangered plants and animals within the planned well construction areas. This habitat survey data and information provided by the University of California will be used to minimize impact to the habitat and special-status species within FONR. Where practicable, adjustments will be made to construction plans (e.g., adjustments to monitoring well location) and coordinated with the University of California to minimize the impact on natural resources.

The field activities in the FONR include installation of a new extraction well and vault, conduit, pipeline, and tie-in vault. The locations where construction activities will occur are shown in Figure 7 and will be identified in the Habitat Checklist (Attachment G) prior to commencing fieldwork. Field personnel will receive training to familiarize them with the site restrictions necessary to minimize impacts to the habitat and special-status species on FONR lands. During each of these activities, staging areas and specific access routes will be established to minimize excess impact to the ground surface, such as rutting and erosion. Mats will be used where necessary to protect vegetation and prevent damage to the ground surface, including activities such as the operation of vehicles off of existing roads and creation of new access routes.

The Onsite Biologist will monitor work as necessary to ensure conservation measures are implemented. Baseline and 3-year follow-up monitoring will be conducted to determine if special-status species have been adversely impacted and if corrective measures are recommended. Because the corrective actions will take place in the FONR, which is one of several sites administered by the University of California, the Onsite Biologist will coordinate with the University of California, the USACE Technical Lead, and the BRAC Office Biologist prior to implementation.

Following field activities, disturbed land around the wells will be restored as closely as possible to its original condition by limited grading after coordination with the USACE Technical Lead and the BRAC Office Biologist.

9.5.3 Water Resources Protection

The potential for impact to surface water resources is assumed to be minimal because there is no surface water drainage or storm drains that lead to surface water within the project sites. Equipment maintenance and fueling will be conducted offsite and away from open storm drain inlets.

9.5.4 HMP Species

Project activities undertaken must protect and maintain the special-status species found within FONR. Efforts are taken to avoid or minimize impacts to HMP species, with emphasis on three federally listed plant species: Monterey spineflower, Monterey gilia, and Yadon's piperia. Special-status species listed in the HMP and Programmatic Biological Opinion (USFWS, 2017) that occur or may occur on FONR include:

- Monterey gilia (*Gilia tenuiflora* ssp. *arenaria*) – federally endangered, state threatened
- Monterey spineflower (*Chorizanthe pungens* var. *pungens*) – federally threatened
- Seaside bird's beak (*Cordylanthus rigidus* ssp. *littoralis*) – state endangered
- Sandmat manzanita (*Arctostaphylos pumila*)
- Monterey manzanita (*Arctostaphylos montereyensis*)
- Monterey ceanothus (*Ceanothus rigidus*)
- Eastwood's goldenbush (*Ericameria fasciculata*)
- Yadon's piperia (*Piperia yadonii*) – federally endangered
- Coast wallflower (*Erysimum ammophilum*)
- California black legless lizard (*Anniella pulchra nigra*; BLL) – state species of concern

- California tiger salamander (*Ambystoma californiense*; CTS) – federally threatened, state threatened
- Monterey ornate shrew (*Sorex ornatus salarius*) – state species of concern

Monterey gilia, Monterey spineflower, Seaside bird's beak, and coast wallflower are annual herb species that may occur within maritime chaparral, coastal scrub, grasslands, dune scrub, or disturbed areas. Sandmat manzanita, Monterey manzanita, Monterey ceanothus, and Eastwood's goldenbush are perennial shrub species that typically occur in maritime chaparral, but individuals can also be found mixed with oak woodland or coastal scrub habitats. Yadon's piperia is a perennial herb that is typically found in maritime chaparral and Monterey pine habitats.

The BLL is a rare variety of the California legless lizard (*Anniella pulchra*) that inhabits areas with sandy soils on the former Fort Ord. The Monterey ornate shrew is a rare variety of the ornate shrew (*Sorex ornatus*) found in riparian forest and oak woodland habitats. The CTS is typically found in vernal or seasonal ponds on the former Fort Ord. The CTS may also be found aestivating in small mammal burrows or under logs in upland areas within 2.2 kilometers of vernal ponds.

As identified in the Programmatic Biological Opinion (USFWS, 2017), success criteria for contaminated groundwater remediation are as follows:

After the final monitoring period for each of the federally listed species or designated Monterey spineflower critical habitat, species reestablishment will be considered successful when:

1. *densities and acreage of HMP annual species are within a normal range compared with information from reference sites, and;*
2. *the number of wells where HMP annual species are detected in follow-up surveys will be the same or greater than the number of wells where these species were found in baseline surveys.*

If the success criteria are not met, based on the evaluation of the monitoring data, corrective measures will be developed in coordination with the U.S. Fish and Wildlife Service, as specified in the Programmatic Biological Opinion (USFWS, 2017).

9.5.5 HMP Species Protection

The Onsite Biologist will identify areas containing populations of Monterey gilia and Monterey spineflower during baseline surveys. Access routes will be delineated with rope or flagging tape to ensure personnel and equipment stay within designated work areas and prohibit access to protected areas. The Onsite Biologist will ensure conservation measures are implemented during well installation activities in the FONR and will be available to resolve unanticipated resource issues as they arise.

Ahtna will communicate to personnel working at the site the resources of concern and habitat protection requirements prior to the start of field activities. Staging areas, access routes, and turnaround areas will be clearly delineated and shown to field personnel. Field personnel will be instructed to lock any access gate behind them after each entry to and exit from the FONR. If a BLL or CTS is discovered during the proposed activities, the Onsite Biologist will be immediately notified. The Onsite Biologist will coordinate with the BRAC Office Biologist to confirm appropriate conservation steps, including relocation, if necessary. The Onsite Biologist will fill out the field observation form with the necessary information and then relocate the individual, if necessary, to suitable nearby habitat. If the Onsite and/or BRAC Office Biologist are not available onsite during observation of CTS or BLL, onsite personnel may carefully relocate BLL away from fieldwork if harm is imminent and fill out the biological observation form (Attachment G). Work must stop if CTS is observed until an approved Biologist has removed the CTS from the project site.

When driving vehicles and heavy equipment through the inner roads of the FONR area, personnel must walk in front of vehicles to ensure there are no Coast Horned Lizards (*Phyrnosoma blainvilli*) in the road before the vehicle passes.[5] If Coast Horned Lizards are observed, they must be relocated away from the vehicle's path. Observations of Coast Horned Lizards may be reported to the University of California and the BRAC Office Biologist for tracking purposes.

Some limited vegetation clearance may be necessary to access well locations. If necessary, vegetation clearance will be coordinated with the University of California, the BRAC Office Biologist, and USACE Technical Lead, and conducted following standard best management practices to protect the existing oak trees and special-status species. Tree branches may be trimmed as necessary to provide access, but no trees will be removed. Vegetation removed from work areas will be consolidated with other construction debris and taken to an appropriate disposal facility.

9.6 Quality Control Tasks

For USACE projects, Ahtna implements the three-phase QC process. For tasks that include definable features of work with daily field activities, Ahtna will prepare a daily status report package, which will include:

- Daily Field Report
- Three-Phase QC Report
- Daily Site Safety Tailgate/Inspection Log.
- Copies of daily logs and documentation to support work completion and payment milestones.

Samples of report forms are included in Attachment E. Daily status reports will be submitted to the designated USACE QA Officer as necessary. Ahtna will also prepare and submit to the USACE monthly status reports summarizing task activities. These reports will include descriptions of QC issues identified for resolution, corrective actions that were taken, and a brief description of scheduled or anticipated activities in the next period.

9.7 Documentation and Records

Field records will be maintained and be sufficient to thoroughly document field activities. The information will be recorded in a permanently bound notebook with sequentially numbered pages. The following information will be recorded for field activities: (1) location, (2) date and time, (3) people performing activity, (4) weather conditions, and (5) logs of the activities being conducted. For field measurements: (1) the numerical value and units of each measurement, and (2) the identity of and calibration results for each field instrument will be recorded. Record sample identification numbers and chain of custody numbers, personnel present on site, site conditions, visitors to the site, and significant events and observations.

[5] Coast Horned Lizard is not an HMP species but is a state species of special concern.

Each day of fieldwork, Ahtna will prepare a Project Field Report to describe onsite personnel, visitors, equipment, hours of operation, a summary of activities, quality and safety issues, corrective actions, and photographs. These daily Project Field Reports will be submitted to USACE weekly during fieldwork activities. A logbook will be kept, and documentation will follow the procedures outlined in SOP #FSOP-001.01 (Attachment F). Field forms are shown in Attachment E.

A Completion Report will be prepared to document field activities. The Completion Report will include field data and documentation (well logs, photographs, etc.) collected as part of these activities. Analytical data will also be summarized and interpreted in the Completion Report.

9.8 Project Schedule

The general project schedule below outlines activities and deliverables. The expected timeline is subject to change based on document and field schedule changes. Regular project meetings will be conducted with an updated and detailed schedule for project personnel.

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Baseline Habitat Survey, FONR	Denise Duffy and Associates	April 2024	May 2024	Habitat Checklist	June 2024
Geophysical Utility Clearance	Utility Surveyor	May 2024	May 2024	Maps of detected utilities, GPS coordinates of detected features	June 2024
Pilot Boring	Ahtna/ Driller	June 2024	June 2024	Boring Log	June 2024
Well Installation	Ahtna/ Driller	June 2024	June 2024	Well Completion Diagram	June 2024
IDW Management	Ahtna/SGS	June 2024	June 2024	CQCR/Lab Report	June 2024
Well Development and Specific Capacity Testing	Ahtna/ Driller	June 2024	June 2024	CQCR	June 2024
Well Survey	Surveyor	Aug 2024	Aug 2024	Horizontal and vertical coordinates	Aug 2024
Tie-In Vault and Wellhead Vault Installation	Ahtna/Subs	Aug 2024	Aug 2024	CQCR	Aug 2024
Submersible Pump, Wellhead Vault Piping,	Ahtna/Subs	Aug 2024	Sept 2024	CQCR	Sept 2024

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
and Wellhead Instrumentation Installation					
Trenching, Conduit Install, Bunker Hill Vault Tie-In	Ahtna/Subs	July 2024	July 2024	CQCR/As-Built	July 2024
Pressure Test Pipe, Backfill Trench	Ahtna/Subs	July 2024	July 2024	CQCR	July 2024
Upgrade Bunker Hill PLC Panel	Ahtna/Subs	Sept 2024	Sept 2024	CQCR	Sept 2024
Installation of Wire	Ahtna/Subs	Sept 2024	Sept 2024	CQCR	Sept 2024
System Startup and Hydrogeologic Testing	Ahtna/Subs	Oct 2024	Oct 2024	CQCR	Oct 2024
Incorporate EW-OU2-13-180 into OU2 GWTS O&M	Ahtna/Subs	Oct 2024	Oct 2024	CQCR	Oct 2024
Sample Collection, Analysis, and Validation	Ahtna/SGS/ LDC	Oct 2024	Oct 2024	CQCR/Lab Package/VSR	Oct 2024
Completion Report	Ahtna	Nov 2024	Jan 2025	Completion Report	Jan 2025
OU2 GWTS O&M Manual Revision	Ahtna	Feb 2025	Mar 2025	OU2 GWTS O&M Manual Revision 5	Mar 2025

Notes:
CQCR: Contractor Quality Control Report
LDC: Laboratory Data Consultants
SGS: SGS North America, Inc.
VSR: Validation Summary Report

9.9 Other Tasks

See Groundwater QAPP Revision 11 (Ahtna, 2023b) Worksheet #14 & 16 for information about:

- QC Tasks
- Data Management Tasks
- Sample Tracking
- Data Types
- Data Tracking and Management

- Computer Database
- Geographic Information System
- Data Management Documentation
- Presentation of Data
- Assessment and Audit Tasks
- Data Review Tasks

10.0 Worksheet #15: Laboratory Specific Detection/Quantitation Limits

10.1 Worksheet #15a: VOCs by EPA Method 8260-SIM

The laboratory specific detection/quantitation limits for VOCs are included in Groundwater QAPP Revision 11 (Ahtna, 2023b).

10.2 Worksheet #15b: Ion Chromatography by EPA Method 9056A

Matrix: Groundwater

Analyzing Laboratory: SGS North America, Inc. (SGS)[1]

Analyte	CAS Number	Achievable Laboratory Limits[2] (mg/L)		
		DL	LOD	LOQ
Nitrite	7632-00-0	0.04	0.05	0.1
Nitrate	14797-55-8	0.04	0.05	0.1
Sulfate	7757-82-6	0.6	1	2.0

Notes:
CAS: Chemical Abstracts Service
DL: detection limit
LOD: limit of detection
LOQ: limit of quantitation
mg/L: milligrams per liter
[1] Laboratories used for sample analysis maintain DoD Environmental Laboratory Accreditation Program certification (provided in Attachment E of Groundwater QAPP Revision 11 [Ahtna, 2023b]).
[2] Achievable DLs, LODs, and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. An analyte is ND at the LOD, and a measurable detection above the DL and less than the LOQ is estimated ("J-qualified").

10.3 Worksheet #15c: Dissolved Metals by EPA Method 6010D

Matrix: Groundwater

Analyzing Laboratory: SGS[1]

Analyte	CAS Number	Achievable Laboratory Limits[2] (µg/L)		
		DL	LOD	LOQ
Iron	7439-89-6	17	50	300
Manganese	7439-96-5	1.0	2.0	15

Notes:
CAS: Chemical Abstracts Service
DL: detection limit
LOD: limit of detection

LOQ: limit of quantitation
µg/L: micrograms per liter
[1] Laboratories used for sample analysis maintain DoD Environmental Laboratory Accreditation Program certification (provided in Attachment E).
[2] Achievable DLs, LODs, and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. An analyte is ND at the LOD, and a measurable detection above the DL and less than the LOQ is estimated ("J-qualified").

11.0 Worksheet #17: Sampling Design and Rationale

The field activities will be conducted in general accordance with the SOPs included in Attachment F. Daily field conditions and tasks will be recorded in the Field Logbook and Daily Field Report forms in Attachment E.

11.1 Baseline Groundwater Sampling

Baseline groundwater sampling will be conducted as part of the well installation and startup procedure. The baseline sampling will be conducted prior to long-term operation of extraction well EW-OU2-13-180 and will include a comprehensive evaluation of COCs and hydrochemistry. Baseline sampling will be conducted in two phases:

1. After installation and development of new extraction well EW-OU2-13-180, sampling includes installation of a weighted rope with sampling stations at approximately five-foot intervals in the well screen zone, placement of PDBs at each saturated station for profiling the water column, and collecting samples at least two weeks after placement of the PDBs to determine the zone of highest OU2 COC concentrations. These data will be used in combination with borehole log, well development, and specific capacity testing data to determine appropriate permanent submersible pump depth.

2. After installation of the submersible pump and connection to the OU2 GWTS, EW-OU2-13-180 will be sampled at the wellhead for OU2 COCs, dissolved metals, and anions. These data will be used as a basis for comparison with future analytical results to evaluate extraction well performance per the OU2 GWTS O&M Manual.

The Phase 2 baseline sampling event will include a single sample from extraction well EW-OU2-13-180 to evaluate the pre-treatment concentrations of COCs and to establish the local in situ hydrochemistry of the Upper 180-Foot Aquifer. The Phase 2 baseline sampling will be conducted no sooner than 72 hours after development of the well and will include the following:

- Water quality parameters – pH, temperature, conductivity, turbidity, dissolved oxygen, and oxidation reduction potential
- VOCs – EPA Method 8260-SIM
- Anions – EPA Method 9056A
    - nitrate
    - nitrite
    - sulfate
- Dissolved metals – EPA Method 6010D
    - iron
    - manganese

Subsequent sampling will be conducted as part of the Fort Ord Basewide quarterly GWMP and subject to Groundwater QAPP decision rules to determine sampling frequency. Groundwater samples will be collected and analyzed according to Groundwater QAPP Revision 11 (Ahtna, 2023b).

11.1.1 Groundwater Sampling Procedure

Baseline sampling of extraction well EW-OU2-13-180 will be consistent with Groundwater QAPP Revision 11 (Ahtna, 2023b). Baseline sampling will be conducted in two phases: 1) PDBs for profiling the water column prior to pump installation; and 2) sample collection from the sample port in the well vault with the pump operating.

11.1.2 Laboratory Analytical Requirements

The baseline groundwater samples will be collected and submitted to an off-site laboratory for selected analysis. The specific analyses that will be completed by the off-site laboratories include:

- VOCs by EPA Method 8260 SIM
- Dissolved metals (iron and manganese) by EPA Method 6010D
- Anions (nitrate, nitrite, and sulfate) by EPA Method 9056A

The specific requirements for these methods, including sample collection and preservation, laboratory QC, laboratory QA, laboratory corrective action, data management, and QA oversight, are described in Groundwater QAPP Revision 11 (Ahtna, 2023b).

11.2 Soil IDW Sampling

Two representative soil samples will be collected from borehole cuttings according to the SOPs in Attachment F and analyzed for the OU2 COCs listed in Groundwater QAPP Revision 11 by EPA Method 8260D (Ahtna, 2023b).

11.3 Analytical

Baseline sampling will be conducted after the development of the new well and during the next scheduled quarterly sampling event associated with the GWMP following well development. Accordingly, QC samples will also be collected and samples will be analyzed by EPA Method 8260-SIM for volatile organic analysis following the sampling and laboratory analytical protocols identified in Groundwater QAPP Revision 11 (Ahtna, 2023b).

The target analyte list for the baseline samples will be OU2 COCs per Groundwater QAPP Revision 11 (Ahtna, 2023b). Laboratory analytical data collected under this task will be maintained, uploaded to the Fort Ord Data Integration System site, and validated in accordance with Groundwater QAPP Revision 11 (Ahtna, 2023b)

11.4 Reporting

The QAPP Addendum activities will be documented in a Completion Report, which will describe work associated with the construction of the new OUCTP extraction well and tie-in to the existing OU2 GWTS including, but not necessarily limited to, field data, documentation, well completion diagrams, geologic logs, well development records, photographs, sampling analytical data, data interpretation, and results from the step-drawdown and constant-rate pumping tests. The Completion Report will also document deviations from the work approach or project design as described in this QAPP Addendum. Construction as-built drawings associated with this project will be included in a revision to the OU2 GWTS O&M Manual.

12.0 Worksheet #18: Sampling Locations and Methods

This Worksheet facilitates completeness checks to ensure planned samples have been collected and appropriate methods have been used.

Location	Matrix	Depth (ft bgs)	Type	Analyte/Analytical Group	Sampling SOP	Comments
EW-OU2-13-180	Soil	0-225	Composite	VOCs/OU2	FSOP-405.01	IDW
EW-OU2-13-180	GW	185-225 (to be determined based on screen interval)	PDB[1]	VOCs/OU2	FSOP-402.02[2]	Before pump installation
		Depth of Pump (to be determined)	Sample port	VOCs/OU2 Dissolved Metals Anions	FSOP-401.01	Following pump installation with pump operating

Notes:

[1] Baseline sampling includes placement of PDBs at each saturated sampling station for profiling the water column.

[2] PDB sampling protocol is in Attachment A to Groundwater QAPP Revision 11 (Ahtna, 2023b).

ft bgs: feet below ground surface
GW: groundwater
OU2: Operable Unit 2
PDB: passive diffusion bag
SOP: standard operating procedure
VOC: volatile organic compound.

13.0 Worksheet #19 & 30: Sample Container, Preservation, and Hold Times

Laboratory: SGS
4405 Vineland Rd, Suite C-15
Orlando, FL 32811
Telephone: (407) 425-6700

Point of Contact: Svetlana Izosimova
Email: Svetlana.Izosimova@sgs.com

Sample Delivery Method: Courier to San Jose, California distribution center or FedEx overnight shipment to Florida

Matrix	Analytical Group[1]	Preparation/Analytical Method	Sample Volume	Containers	Preservation	Holding Time	Data Package Turnaround
Groundwater	Nitrate Nitrite	EPA 9056A	100 mL	One 250-mL HDPE bottle	Sample temp > 0°C ≤ 6°C	48 hours	15 business days
	Sulfate					28 days	

Notes:
°C: degrees Celsius
HDPE: high-density polyethylene
mL: milliliter
[1] Sample container, preservation and holding time for VOCs and dissolved metals are provided in Groundwater QAPP Revision 11 (Ahtna, 2023b)

14.0 References[6]

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U.S. Department of the Army (Army), 1997a. *Explanation of Significant Differences, Consolidation of Remediation Waste in a Corrective Action Management Unit (CAMU), Operable Unit 2 Landfill, Fort*

[6] At the end of references included in the Fort Ord Administrative Record are the Administrative Record Numbers (AR#s) (e.g. BW-1234). To find the referenced document, this number may be typed into the online search tool at: http://www.fortordcleanup.com/documents/search/. Please note the referenced documents were available in the Fort Ord Administrative Record at the time this document was issued; however, some may have been superseded by more current versions and were subsequently withdrawn. TBD: to be determined.

Ord, California. January 13. AR# OU2-523.

Army, 1997b. *Record of Decision, Basewide Remedial Investigation Sites, Fort Ord, California*. January 13. AR# RI-025.

Army, 2006. *Explanation of Significant Differences, No Further Action for Munitions and Explosives of Concern, Landfill Gas Control, Reuse of Treated Groundwater, Designation of Corrective Action Management Unit (CAMU) Requirements as Applicable or Relevant and Appropriate Requirements (ARARs), Operable Unit 2, Fort Ord Landfills.* August 15. AR# OU2-656.

Army, 2008. *Record of Decision, Operable Unit Carbon Tetrachloride Plume, Former Fort Ord, California*. February 6. AR# OUCTP-0021D.

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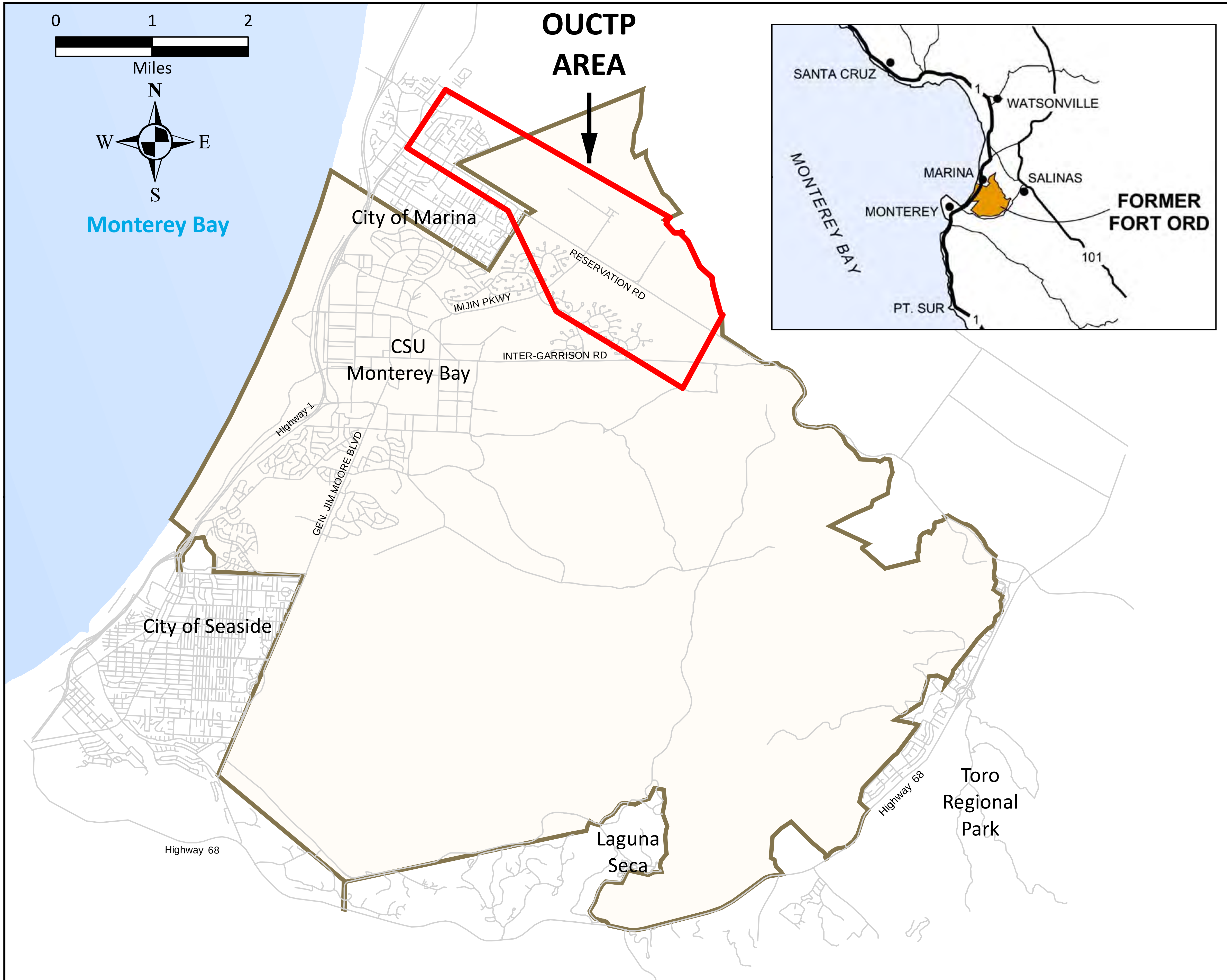
Figures



EXPLANATION

Roads

Operable Unit Carbon Tetrachloride (OUCTP) Area

Former Fort Ord boundary

LOCATION MAP

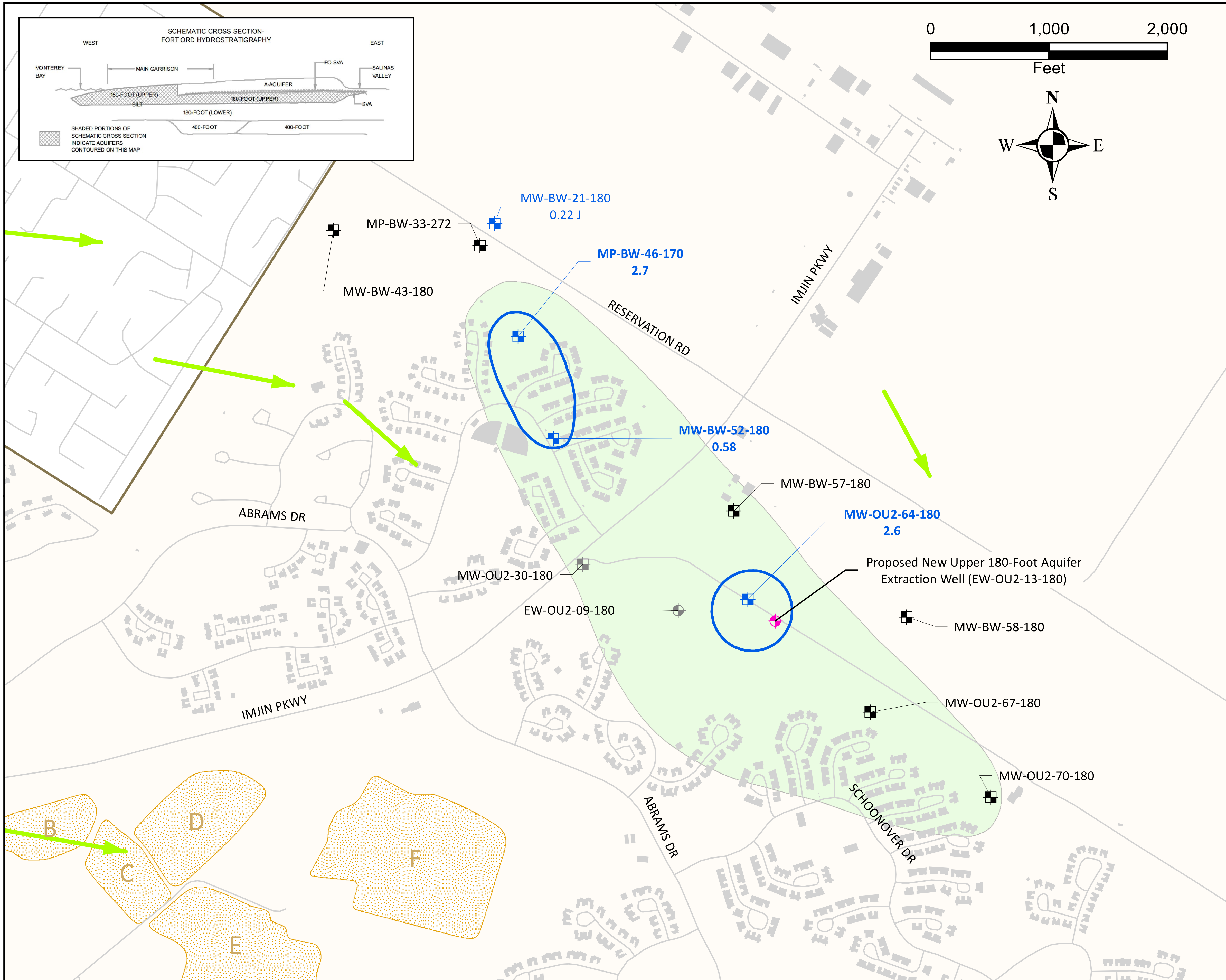
OPERABLE UNIT CARBON TETRACHLORIDE PLUME

Operable Unit Carbon Tetrachloride Plume

Upper 180-Foot Aquifer Extraction Well Installation

QAPP Addendum No. 2, Former Fort Ord, California

Ahtna	Date: 11/3/2022	Figure: 1



EXPLANATION

General groundwater flow direction

Roads

Facilities

Approximate extent of landfill areas (Areas B through F)

Former Fort Ord boundary

Well Type and CT Detection

New Upper 180-Foot Aquifer extraction well (EW-OU2-13-180)

Extraction well not sampled

Monitoring well with carbon tetrachloride (CT) detected

Monitoring well with no CT detected

Monitoring well not sampled

Chemical of Concern (COC) Aquifer Cleanup Level (ACL) exceedance contour in µg/L.

0.5 Carbon tetrachloride (CT) plume

OUCTP Upper 180-Foot Aquifer Hydraulic Zone

6

MW-OU2-64-180
2.6
Well ID - Bold When Concentration Exceeds the ACL for CT
CT Concentrations (µg/L) and validation/lab qualifier.

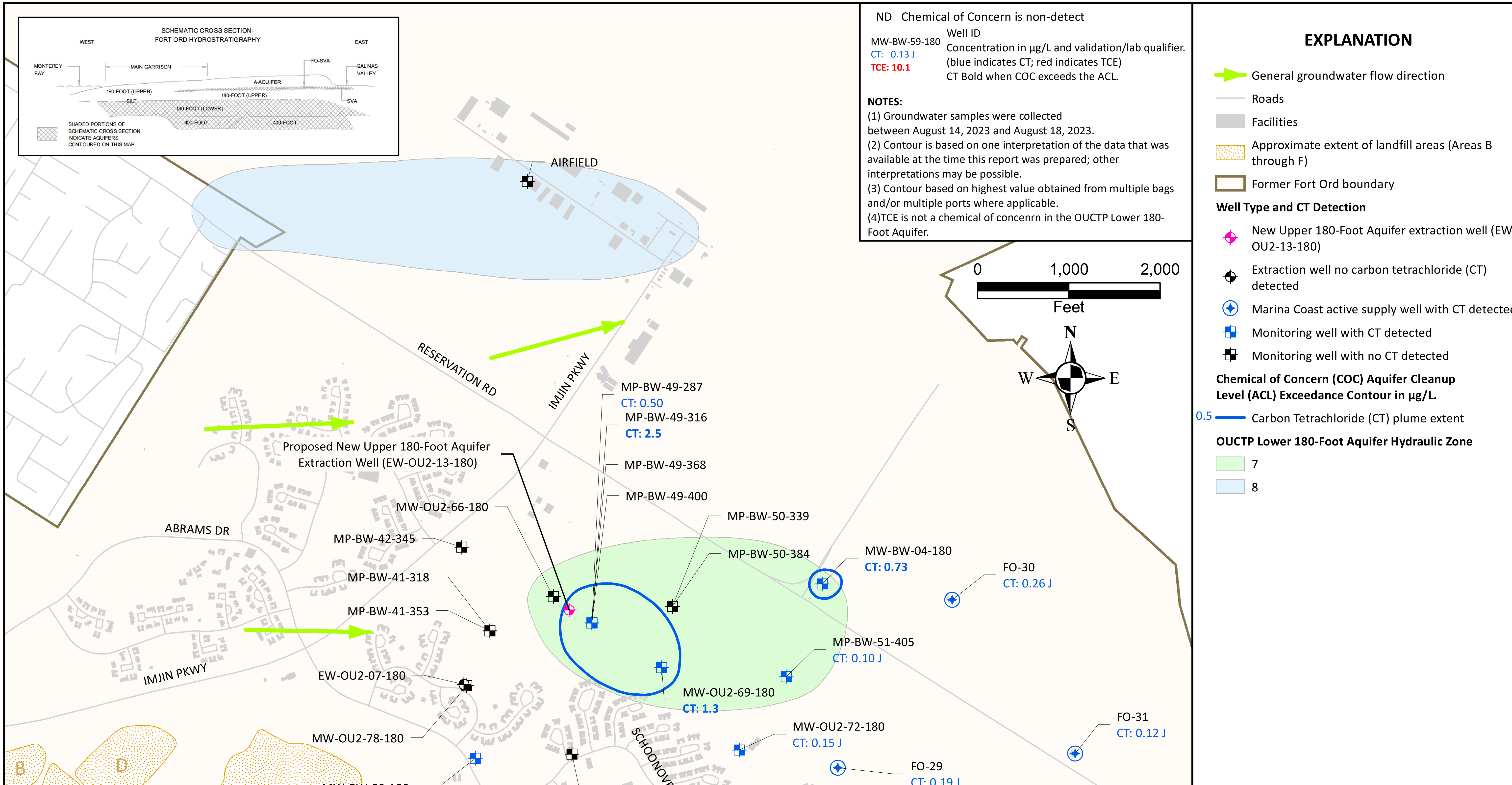
NOTES:

(1) Samples were collected between Augustl 14, 2023 and August 18, 2023.
(2) Contours are based on one interpretation of the data that were available at the time this report was prepared; other interpretations may be possible.
(3) Contours are based on highest value obtained from multiple bags and/or multiple ports were applicable.
(4) Contours near wells not sampled this quarter are inferred from previous analytical data.

CARBON TETRACHLORIDE PLUME
UPPER 180-FOOT AQUIFER
THIRD QUARTER 2023

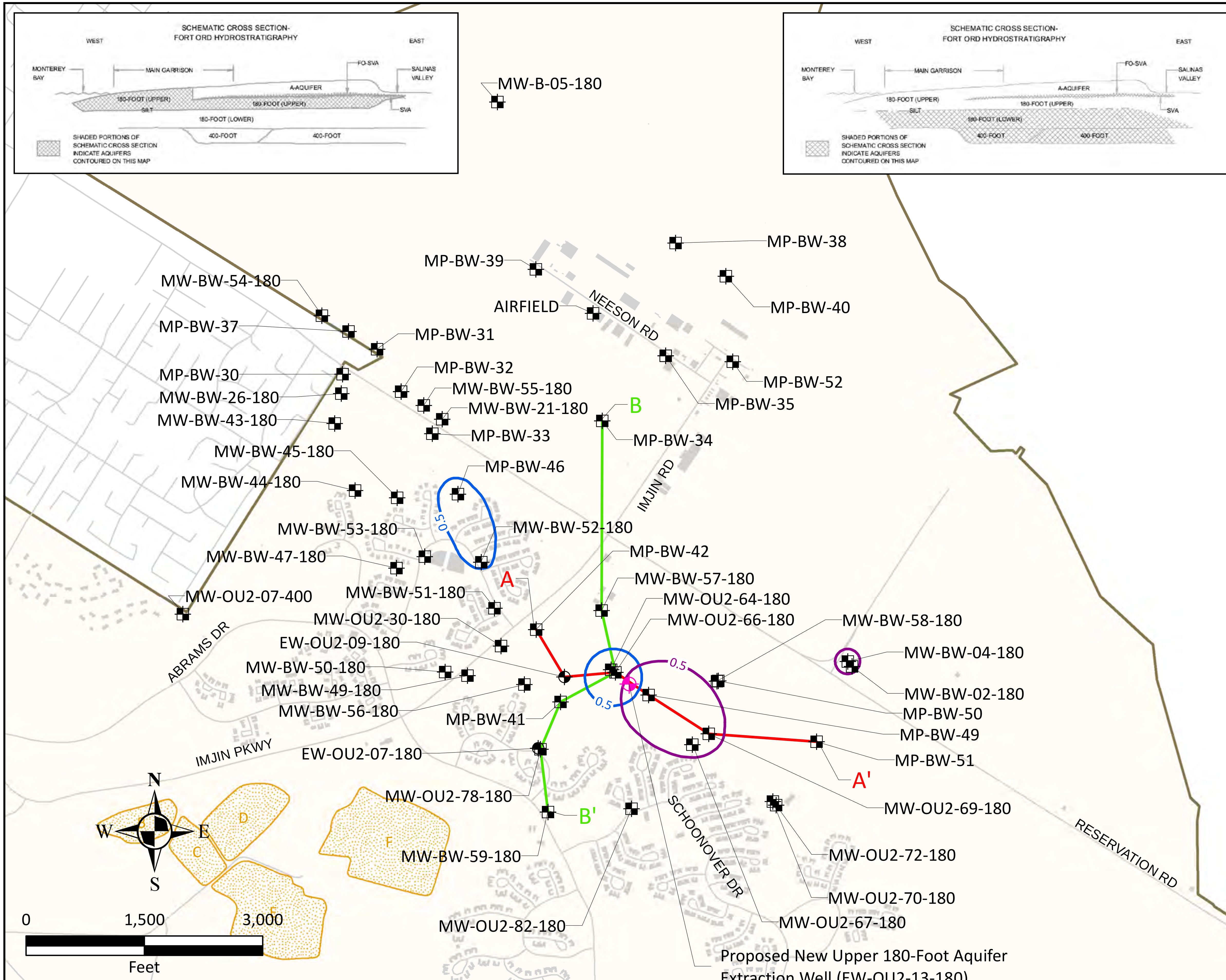
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Well Installation QAPP
Addendum No. 2, Former Fort Ord, California

Ahtna | Date: 3/16/2024 | Figure: 2



CARBON TETRACHLORIDE PLUME
LOWER 180-FOOT/400-FOOT AQUIFERS
THIRD QUARTER 2023
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Well Installation QAPP
Addendum No. 2, Former Fort Ord, California

Ahtna | Date: 3/16/2024 | Figure: 3



EXPLANATION

Roads

Facilities

Former Fort Ord boundary

Approximate extent of landfill areas (Areas B through F)

Well Type

New Upper 180-Foot Aquifer extraction well (EW-OU2-13-180)

Extraction well

Monitoring well

Cross Sections

Cross Section A - A'

Cross Section B - B'

3Q2023 Chemical of Concern (COC) Aquifer Cleanup Level (ACL) Exceedance Contour in µg/L.

0.5 Upper 180-Foot aquifer carbon tetrachloride (CT) plume extent

0.5 Lower 180-Foot aquifer CT plume extent

CARBON TETRACHLORIDE PLUME AND CROSS SECTION MAP
THIRD QUARTER 2023
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Well Installation QAPP
Addendum No. 2, Former Fort Ord, California

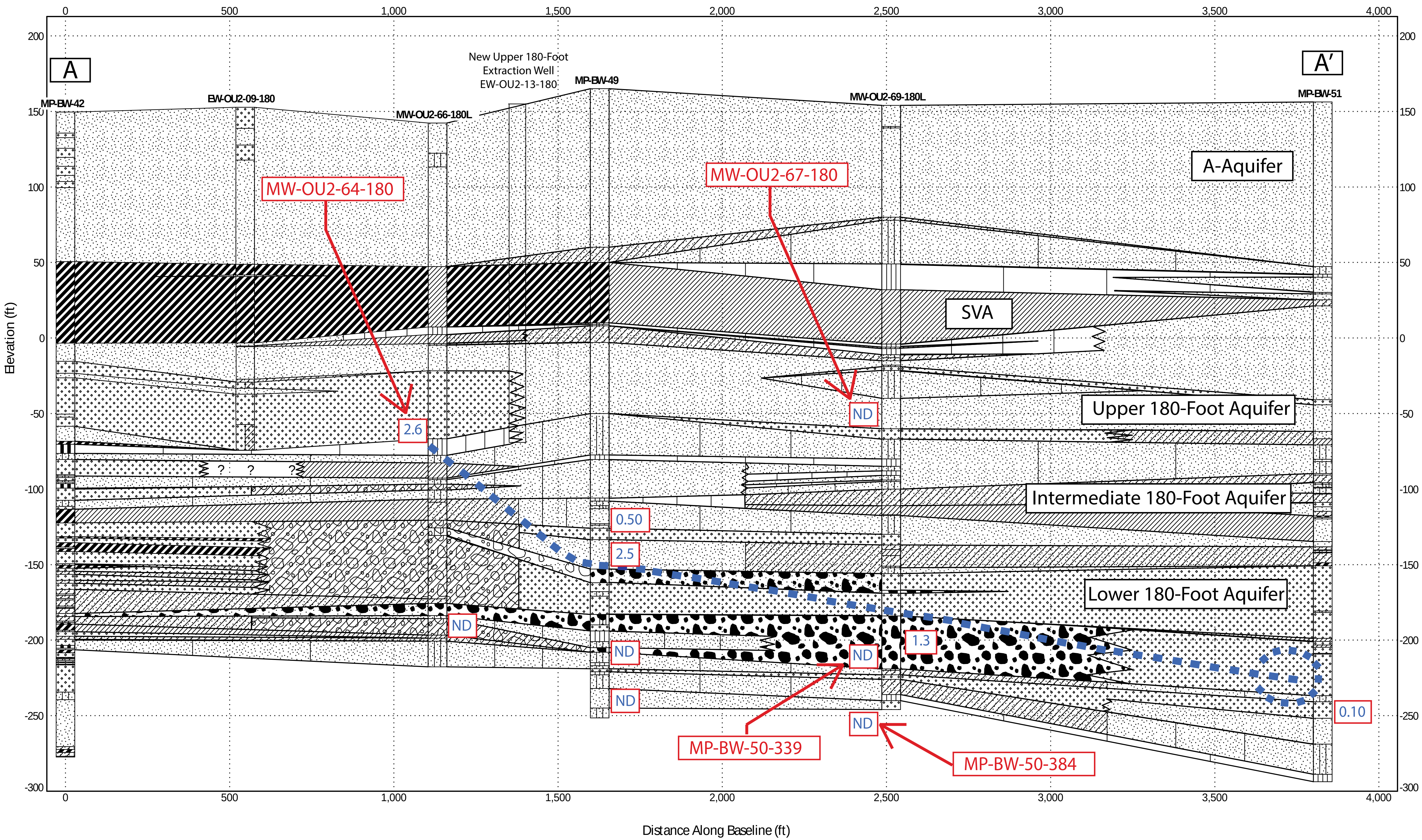
Ahtna | Date: 11/30/2023 | Figure: 4

Project Name: OUCTP Upper 180-Foot Aquifer Extraction
Well Project Location: Former Fort Ord, California
Client: U.S. Army Corps of Engineers
Project Number: W9123823C0026

SUBSURFACE DIAGRAM A-A'

Potential Plume migration pathway from Upper 180-foot Aquifer to Lower 180-foot Aquifer

USCS Well-graded Sand
USCS Low Plasticity Clay
USCS Elastic Silt
USCS Poorly-graded Sand with Silt
USCS Poorly-graded Sand
USCS Clayey Sand
USCS Silty Sand
USCS Well-graded Gravel
USCS High Plasticity
USCS Well-graded Sand with Clay
USCS Silt
USCS Well-graded Gravel with Silt



Ahtna

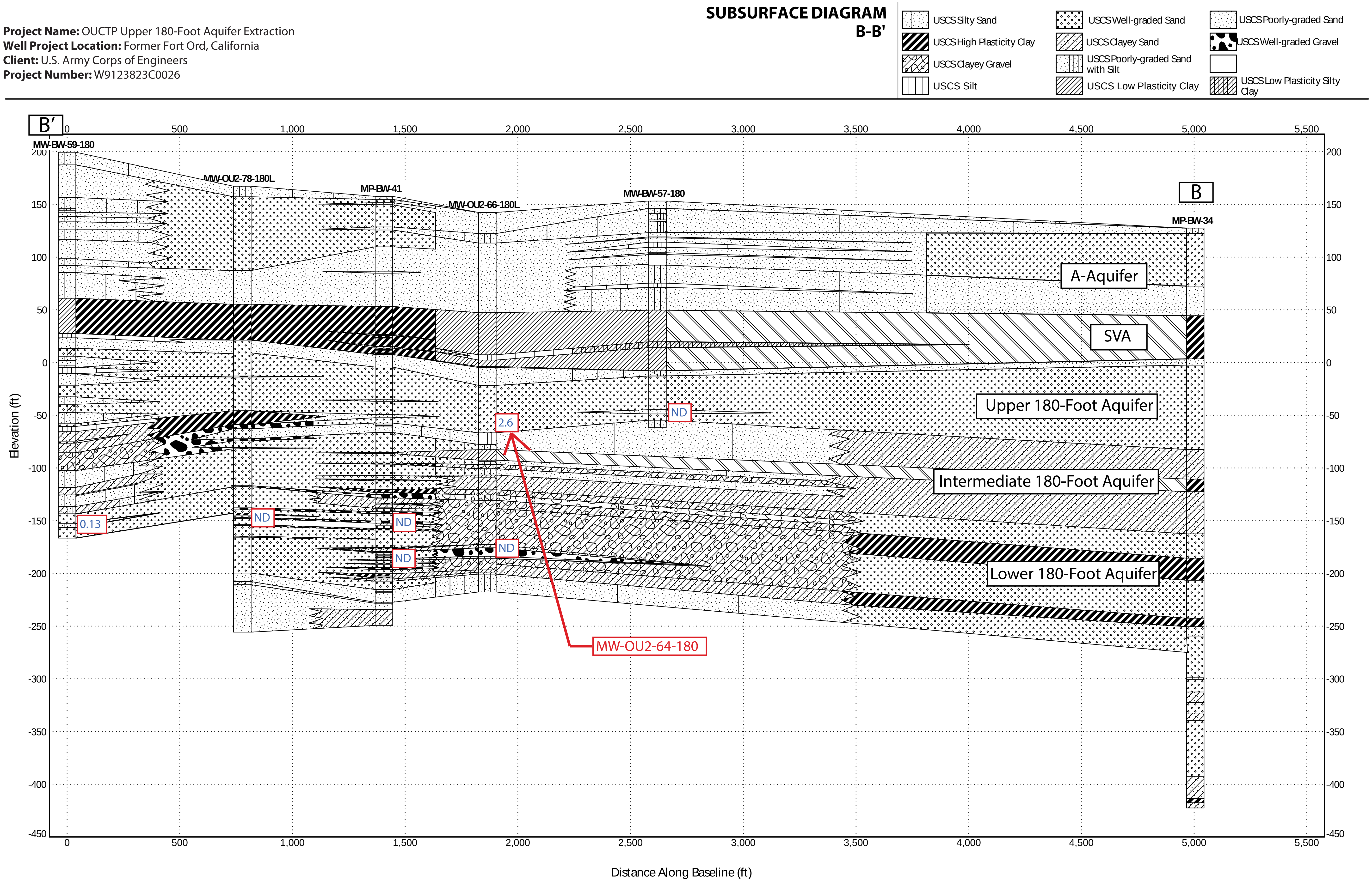
Date: 11/30/2023

CROSS SECTION A-A' CARBON TETRACHLORIDE PLUME
THIRD QUARTER 2023
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Well Installation QAPP
Addendum No. 2, Former Fort Ord, California

Figure: 5

Project Name: OUCTP Upper 180-Foot Aquifer Extraction
Well Project Location: Former Fort Ord, California
Client: U.S. Army Corps of Engineers
Project Number: W9123823C0026

SUBSURFACE DIAGRAM B-B'

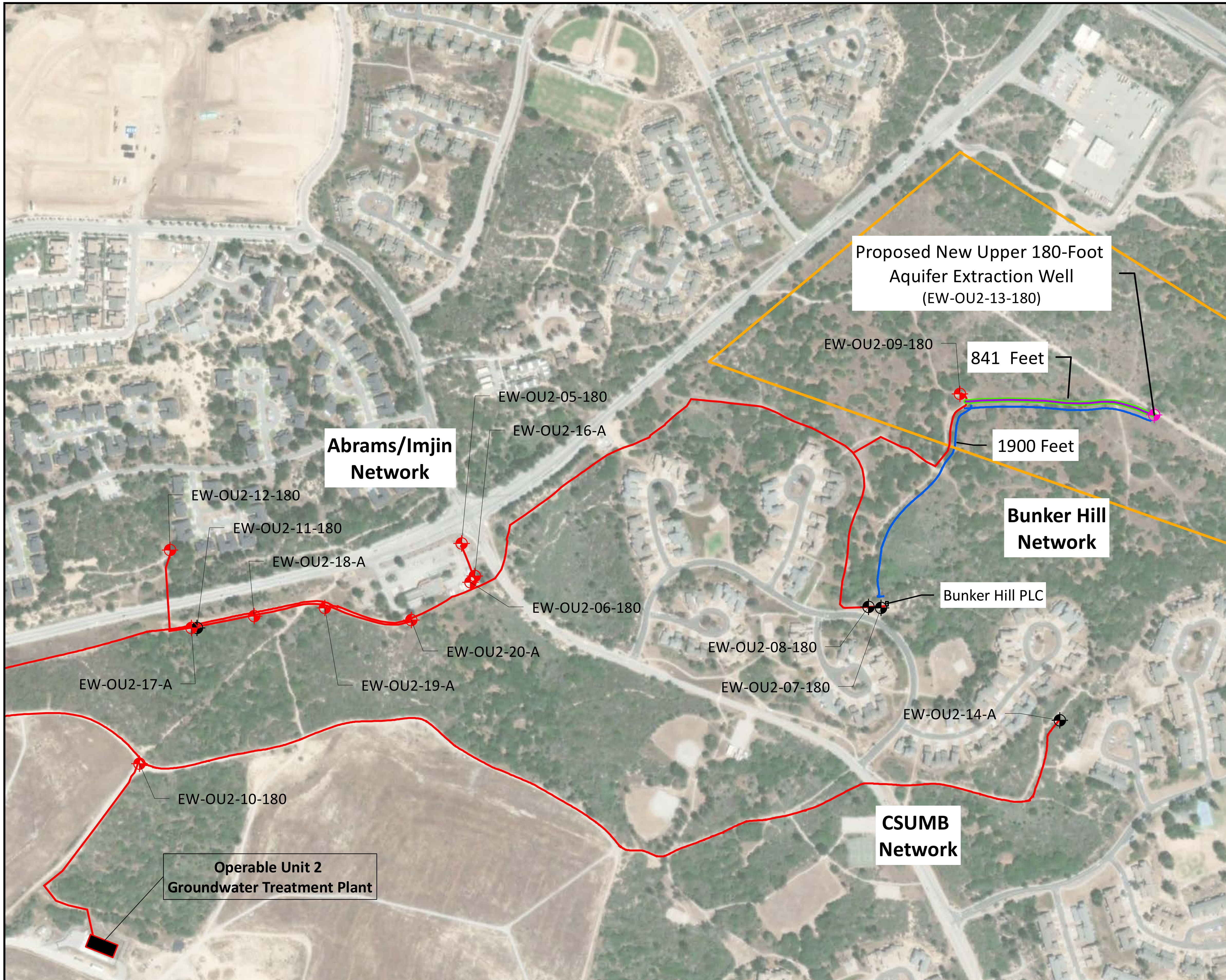


Ahtna

Date: 11/30/2023

CROSS SECTION B-B' CARBON TETRACHLORIDE PLUME
THIRD QUARTER 2023
Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Well Installation QAPP
Addendum No. 2, Former Fort Ord, California

Figure: 6



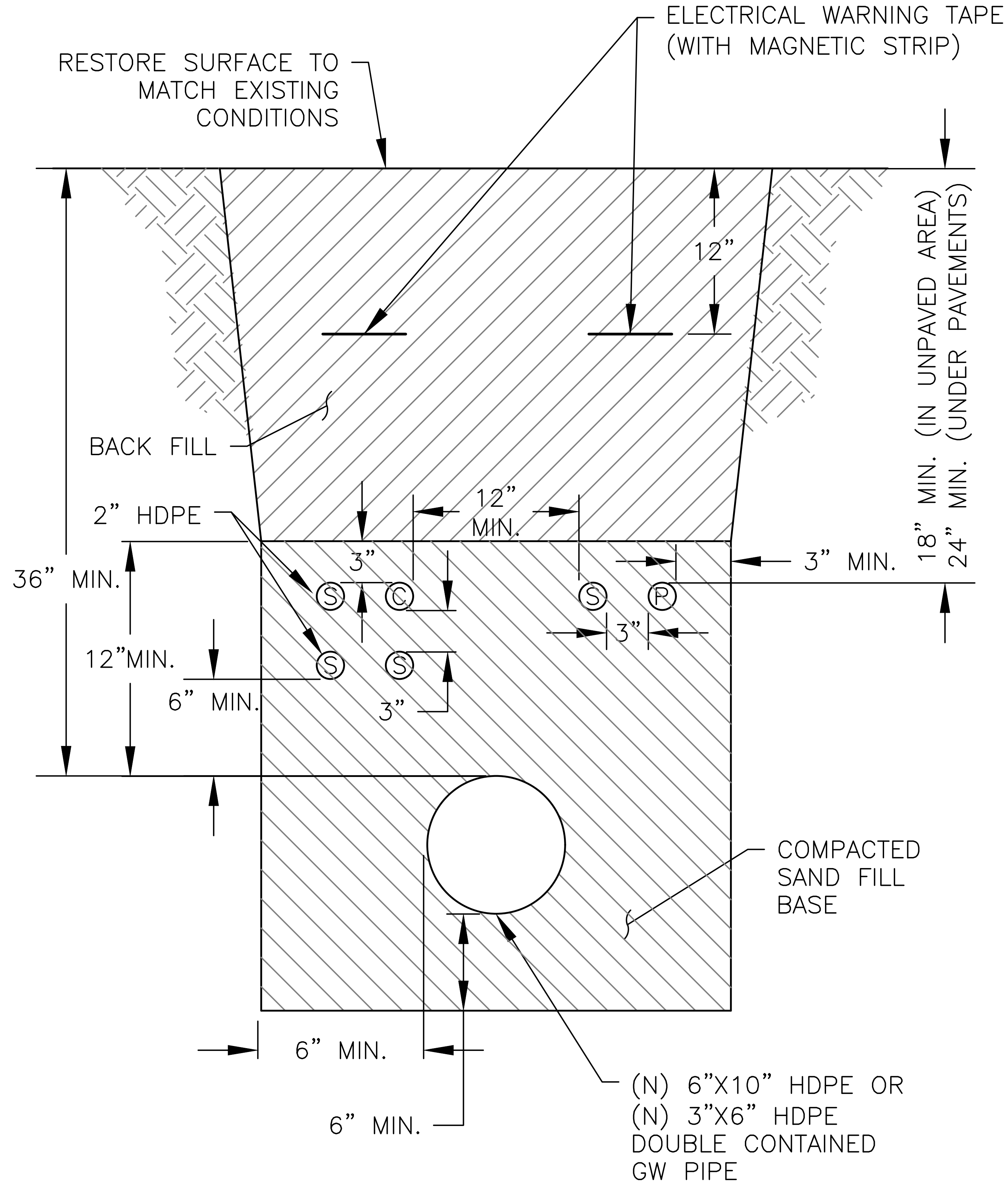
EXPLANATION

- New Upper 180-Foot Aquifer extraction well
- Extraction well operated
- Extraction well not operated
- Proposed untreated water conveyance pipeline to connect to EW-OU2-09-180 existing pipeline (Total 841 feet)
- Groundwater collection pipeline
- New Electrical Power and Control Conduits (Total 1900 feet)
- Fort Ord Natural Reserve (South-West)

PROPOSED UPPER 180-FOOT AQUIFER EXTRACTION WELL LOCATION AND CONVEYANCE ROUTE

Operable Unit Carbon Tetrachloride Plume
Upper 180-Foot Aquifer Extraction Well Installation
QAPP Addendum No. 2, Former Fort Ord, California

Ahtna | Date: 9/7/2023 | Figure: 7



CONDUIT LEGEND

Ⓒ – CONTROL CONDUIT (2" PVC)
Ⓟ – POWER CONDUIT (2" PVC)
Ⓢ – SPARE CONDUIT (2" PVC U.N.O.)

TYPICAL EXTRACTION CONVEYANCE LINE CONSTRUCTION

Operable Unit Carbon Tetrachloride Plume Upper 180-Foot Aquifer Extraction Well Installation QAPP Addendum No. 2, Former Fort Ord, California

Ahtna	Date: 11/5/2022	Figure: 8

Table

Table 1. Extraction Well Materials and Construction

<table>
<tr><th>Well Type</th><th>Casing Type</th><th>Casing Diameter (in)</th><th>Screen Length (ft)</th><th>Screen Type</th><th>Screen Slot (in)</th><th>Sump</th><th>Backfill</th><th>Filter Pack[1]</th><th>Transition Sand[2]</th><th>Bentonite Seal</th><th>Grout Seal</th><th>Pump Piping Type</th><th>Surface Completion</th></tr>
<tr><td>Extraction well EW-OU2-13-180 in min. 14-inch diameter borehole</td><td>Flush-joint threaded Sch 80 PVC; SS centralizers at 40-foot intervals</td><td>10</td><td>40
(4x 10-foot sections)</td><td>Type 316 SS, continuous wire-wrapped</td><td>0.045</td><td>Type 304 welded SS, 2-ft blank casing and end cap</td><td rowspan="2">bentonite pellets</td><td rowspan="2">SiLibeads® or #8/16 silica sand (8 mesh)</td><td rowspan="2">#60 sand</td><td rowspan="2">3/8-inch pellets or slurry placed by tremie pipe</td><td rowspan="2">5 lbs bentonite, 94-lbs Type I Portland cement, 7 gals clean water</td><td>2-inch diameter Type 304 SS</td><td rowspan="2">8-ft x 6-ft x 4-ft concrete vault with double-hinged aluminum, traffic-rated lid</td></tr>
<tr><td>Piezometer installed in same borehole, offset 1 inch from extraction well casing</td><td>Flush-joint threaded Sch 80 PVC</td><td>1.5</td><td>40
(4x 10-foot sections)</td><td>Sch 80 PVC</td><td>0.020</td><td>Sch 80 PVC, 1-foot blank casing and end cap</td><td>NA</td></tr>
</table>

Notes:

[1] Filter pack sand shall be rounded to subrounded siliceous material free of calcareous grains or material.

[2] Tranistion sand shall be well sorted with predominant grain size of between 0.42 and 0.074 millimeter.

Acronyms and Abbreviations:

EW = extraction well
ft = feet
gal = gallon
in = inch
lb = pound
NA = not applicable
PVC = polyvinyl chloride
Sch = Schedule
SS = stainless steel

Attachments

Attachment A:
Boring Logs and Well Construction Diagrams

Shaw® Shaw Environmental, Inc.

BORING NO. EW-OU2-09-180

PROJECT	Former Fort Ord	PROJECT NUMBER	783751	Datums NAVD88 & NAD 83-Cal Zone 4	COORDINATES: N. 2137463.33
					E. 5749891.44
				FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
0.00								Drill Rig: Speedstar 40K Geologic Core:94mm punch
-1.00	1.0						Note: Well installation included 1-inch piezometer (not depicted in graphic image) installed external to 10-inch well casing. Casing: Schedule 40, screen 20 slot PVC, Top of screen 175 ft-bgs, Base 215 ft-bgs. 1 foot sump.	20 inch conductor casing set to 20 ft-bgs
-2.00	2.0							
-3.00	3.0							
-4.00	4.0							Hand Auger to 5'
-5.00	5.0							
-6.00	6.0							
-7.00	7.0							
-8.00	8.0							
-9.00	9.0				SW		9': Well Graded Sand. Dark Yellowish Brown 10yr4/4.	
-10.00	10.0							
-11.00	11.0							
-12.00	12.0							Arch to 20'
-13.00	13.0							
-14.00	14.0				SP		14': Poorly Graded Sand. Yellowish Brown 10yr5/4, , 20% Fine, 70% Medium,10% Coarse Sand Slightly Moist	Annular Seal: Grout 5% Bentonite-Cement
-15.00	15.0							
-16.00	16.0							PVC Well Casing 10" Schedule 80
-17.00	17.0							
-18.00	18.0						18': Poorly Graded Sand. Yellowish Brown 10yr5/6, , 10% Medium, 90% Coarse. Slightly Moist	
-19.00	19.0							
-20.00	20.0				SP			Bottom of 20" conductor
-21.00	21.0							Mud Property (Pilot Boring) Marsh cone: 43 seconds
-22.00	22.0							
-23.00	23.0							
-24.00	24.0							
-25.00	25.0				SW		25': Well Graded Sand, Yellowish Brown 10yr5/6. 30% Fine, 40% Medium, 30% Coarse	
-26.00	26.0							
-27.00	27.0							
-28.00	28.0							
-29.00	29.0							
-30.00	30.0							

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

PROJECT	Former Fort Ord	PROJECT NUMBER 783751	Datums NAVD88 & NAD 83-Cal Zone 4	COORDINATES: N.	2137463.33
				E.	5749891.44
			FIELD GEOLOGIST: W. Werner	TOC ELEV:	152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV:	155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs	APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010	
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"	TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010	
SCREEN:	Diameter: 10 in.	Length: 40 ft Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43	
CASING	Diameter: 10 in.	Length: 175 ft Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange	
SUMP	Diameter: 10 in.	Length: 5 ft Type SS 304		Units: feet	

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-31.00	31.0							
-32.00	32.0							
-33.00	33.0							
-34.00	34.0							
-35.00	35.0				SP		35': Poorly Graded Sand, Brownish Yellow 10yr6/6 40% Fine, 50% Medium,10% Coarse. Quartzose.	
-36.00	36.0							
-37.00	37.0							
-38.00	38.0							
-39.00	39.0							
-40.00	40.0							Mud Property (Pilot Boring)
-41.00	41.0							Marsh cone: 35 seconds Mud Weight: 9.1 lb/ft^3
-42.00	42.0				SP		42': Same except: 60% Fine, 40% Medium Sand, Trace Coarse,Trace Silt.	
-43.00	43.0							
-44.00	44.0							Annular Seal: Grout 5% Bentonite-Cement
-45.00	45.0							
-46.00	46.0						46': Same except: 40% Fine, 60% Medium Sand.	PVC Well Casing 10" Schedule 80
-47.00	47.0							
-48.00	48.0							
-49.00	49.0							
-50.00	50.0							
-51.00	51.0							
-52.00	52.0				SP		52': Same except, 30% Fine, 70% Medium Sand.	
-53.00	53.0							53' Centralizer
-54.00	54.0							
-55.00	55.0							
-56.00	56.0							
-57.00	57.0							
-58.00	58.0							
-59.00	59.0							
-60.00	60.0				SP		60': Same as above	Mud Property (Pilot Boring) Marsh cone: 34 seconds

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER	783751		FIELD GEOLOGIST: W. Werner	TOC ELEV:	152.31[1]
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary		CHECKED BY: Melinda Montano	GS ELEV:	155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs			APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010	
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"			TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010	
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size	S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43	
CASING	Diameter: 10 in.	Length: 175 ft	Type	PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange	
SUMP	Diameter: 10 in.	Length: 5 ft	Type	SS 304		Units: feet	

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-61.00	61.0							
-62.00	62.0							
-63.00	63.0							
-64.00	64.0							
-65.00	65.0				SP		65': Poorly Graded Sand, Brownish Yellow 10yr6/6 30% Fine, 70% Medium. Quartzose.	
-66.00	66.0							
-67.00	67.0							
-68.00	68.0							
-69.00	69.0							
-70.00	70.0							
-71.00	71.0							
-72.00	72.0							
-73.00	73.0							
-74.00	74.0							Annular Seal: Grout 5% Bentonite-Cement
-75.00	75.0		Sieve (Field) < 1% fines		SP		75': Poorly Graded Sand, Yellowish Brown 10YR 6/4, 20% Fine, 70% Medium, 10% Coarse	
-76.00	76.0							PVC Well Casing 10" Schedule 80
-77.00	77.0							
-78.00	78.0							
-79.00	79.0							
-80.00	80.0		Sieve (Field) < 1% fines		SP		80': Same as above	
-81.00	81.0							
-82.00	82.0							
-83.00	83.0							
-84.00	84.0							
-85.00	85.0				SP		85': Same as above	
-86.00	86.0							
-87.00	87.0							
-88.00	88.0							
-89.00	89.0							
-90.00	90.0		Sieve (Field) 1.5 fines		SP		90': Same as above	
-91.00	91.0							

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER 783751		FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary		CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-92.00	92.0						92': Same except: Few clay chips (possible clay stringer)	
-93.00	93.0							93' Centralizer
-94.00	94.0							
-95.00	95.0				SP		95': Poorly Graded Sand. Yellowish Brown 10yr6/4 Fine - Medium	
-96.00	96.0							
-97.00	97.0							
-98.00	98.0							
-99.00	99.0							
-100.00	100.0				SP		100': Same as above	Mud Property (Pilot Boring)
-101.00	101.0							Marsh cone: 35 Seconds Mud Weight: 9.0 lb/ft3
-102.00	102.0							
-103.00	103.0							
-104.00	104.0				CH		104': Clay with Fine Sand and Silt. Grey 5y5/1. Soft	
-105.00	105.0							Annular Seal: Grout 5% Bentonite-Cement
-106.00	106.0							
-107.00	107.0							PVC Well Casing 10" Schedule 80
-108.00	108.0							
-109.00	109.0							
-110.00	110.0							
-111.00	111.0						111': Thin sand layer	
-112.00	112.0							
-113.00	113.0							
-114.00	114.0							
-115.00	115.0							
-116.00	116.0							
-117.00	117.0							
-118.00	118.0							
-119.00	119.0							
-120.00	120.0				CH		120': Clay, Grey 5y5/1. <5% Fine Sand.	
-121.00	121.0							
-122.00	122.0				CH		122': Clay, Light Olive Gray 5y6/2.	

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER 783751		FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary		CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-123.00	123.0							
-124.00	124.0							
-125.00	125.0							
-126.00	126.0							
-127.00	127.0							
-128.00	128.0							
-129.00	129.0							
-130.00	130.0							
-131.00	131.0							
-132.00	132.0							
-133.00	133.0							133' Centralizer
-134.00	134.0							
-135.00	135.0				CH		135' Clay. Olive Gray - Greenish Gray. Gley1-5/5gy and 5y5/2	
-136.00	136.0							Annular Seal: Grout 5% Bentonite-Cement
-137.00	137.0							
-138.00	138.0							PVC Well Casing 10" Schedule 80
-139.00	139.0							
-140.00	140.0							Mud Property (Pilot Boring) Mud: Weight: 9.0 lb/ft^3 Marsh cone: 33 seconds
-141.00	141.0							
-142.00	142.0							
-143.00	143.0							
-144.00	144.0							
-145.00	145.0							
-146.00	146.0							
-147.00	147.0							
-148.00	148.0							
-149.00	149.0							
-150.00	150.0							
-151.00	151.0							
-152.00	152.0							Clay <10% (17" Boring)
-153.00	153.0				CH			

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER	783751	FIELD GEOLOGIST: W. Werner	TOC ELEV:	152.31[1]
LOCATION	OUCTP	DRILLING METHOD:	Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV:	155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs		APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010	
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010	
SCREEN:	Diameter: 10 in.	Length: 40 ft	Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43	
CASING	Diameter: 10 in.	Length: 175 ft	Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange	
SUMP	Diameter: 10 in.	Length: 5 ft	Type SS 304		Units: feet	

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
							153': Clay, Same as above	
-154.00	154.0							Drilling rate increases
-155.00	155.0							
-156.00	156.0				SP		156': Poorly Graded Sand, Yellowish Brown 10yr5/6.	Clay <10% (17" Boring)
-157.00	157.0							
-158.00	158.0				CL		158': Clay. Olive Gray - Greenish Gray. Gley1-5/5gy	Clay 40% (17" boring)
-159.00	159.0				SP		and 5y5/2. Thin layer.	
-160.00	160.0							Top of bentonite seal: 159.5'
-161.00	161.0							
-162.00	162.0							
-163.00	163.0							
-164.00	164.0							
-165.00	165.0				SP		165': Poorly Graded Sand, 10yr5/4, <5% Very Fine, 15% Medium, 80% Coarse.	
-166.00	166.0							166' Top of trans sand
-167.00	167.0							
-168.00	168.0							
-169.00	169.0							169' Top of 8X16 sand
-170.00	170.0							
-171.00	171.0							
-172.00	172.0							Clay decreased (17" boring)
-173.00	173.0							Hard chips in drilling mud 173' Centralizer
-174.00	174.0							
-175.00	175.0				SP		175': Sand, Yellowish Brown, 10yr5/4, 80% Coarse, 20% Very Coarse.	175' Top of screen Clay in ream-mud: 10% (dark gray chips)
-176.00	176.0							
-177.00	177.0							
-178.00	178.0							
-179.00	179.0							
-180.00	180.0						180': Poorly Graded Clayey Sand , Light Olive Brown	Start Punch Core-180 ft-bgs
-181.00	181.0				SC		2.5y5/3, Sand: 10% Medium, 75% Coarse. Clay-silt > 15%Silt	Clay: 5-10 % (17" Boring) (dark gray chips)
-182.00	182.0			60%			182': Well Graded Clayey Sand, Grayish Brown,10yr 5/2,	Natural Gamma Trend 70-75 API (Clayey)
-183.00	183.0				SW-SC		Sand: 20% Medium, 30% Coarse, 30% Very Coarse, 5%, Gravel, Layered Clays 15%	
-184.00	184.0							

Shaw® Shaw Environmental, Inc.

BORING NO. EW-OU2-09-180

PROJECT: Former Fort Ord	PROJECT NUMBER: 783751	Datums NAVD88 & NAD 83-Cal Zone 4	COORDINATES: N. 2137463.33
			E. 5749891.44
LOCATION: OUCTP	DRILLING METHOD: Mud Rotary	FIELD GEOLOGIST: W. Werner	TOC ELEV: 152.31[1]
DRILL CO.: WDC	Logging: Cuttings, Core 180-220 ft bgs	CHECKED BY: Melinda Montano	GS ELEV: 155.52
DRILLER: Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"	APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010
		TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010
SCREEN: Diameter: 10 in.	Length: 40 ft Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43
CASING: Diameter: 10 in.	Length: 175 ft Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange
SUMP: Diameter: 10 in.	Length: 5 ft Type SS 304		Units: feet

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-185.00	185.0		Sieve (Field) <1% fines					
-186.00	186.0						186' Poorly Graded Sand with Gravel. Gravel up to 5/8", >15% Gravel	
-187.00	187.0				SP			
-188.00	188.0			80%				
-189.00	189.0							
-190.00	190.0						190' Well Graded Sand with Clay. 10yr5/4. Sand: 40% Coarse , 10% Fine, 40% Medium, 10% Very Coarse, upper 2-feet firm, loose below,	Less Clay (17" Boring)
-191.00	191.0							Natural Gamma Trend 65-70 API (silty)
-192.00	192.0		Sieve (Field) 3.00% Fines					Mud Property (Pilot Boring) Solids: 3 % Marsh cone: 34 seconds Weight: 9.0 lb/ft3 Filter Cake; 4 mm
-193.00	193.0			60%				
-194.00	194.0							
-195.00	195.0				SW		195' to 200' Well Graded Sand. Grayish Brown 10yr5/2. Sand: 30% Fine, 30% Medium, 20% Coarse 15% Very Coarse, Trace Gravel, Clay 5% dark gray.	Clay 5% (17" boring) Dark gray clay
-196.00	196.0							
-197.00	197.0		Sieve (Field) 2% fines					
-198.00	198.0			10%				No clay (17" Boring)
-199.00	199.0							
-200.00	200.0							Mud Property (Pilot Boring) Mud: Marsh Cone 34 sec.
-201.00	201.0							
-202.00	201.0			0%				
-203.00	203.0				SW			
-204.00	204.0							
-205.00	205.0						205' to 210' Poorly Graded Sand. Grayish Brown 2.5Y5/3, Grayish Brown 10YR5/2. 20%Fine, 60% Medium, 15% Coarse and 5% very coarse. Trace Silt, Mica	
-206.00	206.0							
-207.00	207.0		Sieve (Field) 5% fines		SW			
-208.00	208.0			10%				
-209.00	209.0							
-210.00	210.0						210'-215' Poorly Graded Clayey-Silty Sand. Grayish Brown 2.5Y5/3 60%Fine,15% Medium 10% Coarse, 5% Very Coarse. 5-10% Clay-Silt, Some Mica.	
-211.00	211.0							Natural Gasmma Trend: 80 API (Clay)
-212.00	212.0		Sieve Field 5% fines		SW-SC			
-213.00	213.0			10%				Mud Property (17" Boring) Mud: Density 9.0 lb/ft^3 3% solids 1.5% sand Filter cake 3/32"
-214.00	214.0							
-215.00	215.0						215' Possible Gravel stringer	215' End Screen

BORING NO. EW-OU2-09-180

Shaw® Shaw Environmental, Inc.

COORDINATES: N. 2137463.33
E. 5749891.44

Datums NAVD88 & NAD 83-Cal Zone 4

PROJECT	Former Fort Ord	PROJECT NUMBER 783751	FIELD GEOLOGIST: W. Werner	TOC ELEV:	152.31[1]
LOCATION	OUCTP	DRILLING METHOD: Mud Rotary	CHECKED BY: Melinda Montano	GS ELEV:	155.52
DRILL CO.	WDC	Logging: Cuttings, Core 180-220 ft bgs	APPROVED BY: Tim Ault P.G.	DATE BEGAN: 07/20/2010	
DRILLER	Cliff Rainbolt	Boring Diameter Pilot 8.5", reamed 17"	TOTAL DEPTH: 227 FEET	DATE FINISHED: 07/29/2010	
SCREEN:	Diameter: 10 in.	Length: 40 ft Type/Size S.Steel, 0.045" slot	Sand Pack: 8x16 (8 Mesh)	Piezo. Elev. 151.43	
CASING	Diameter: 10 in.	Length: 175 ft Type PVC SCH 80	Transition Sand: #60	Note 1: Top of Flange	
SUMP	Diameter: 10 in.	Length: 5 ft Type SS 304		Units: feet	

Elevation (ft amsl)	Depth (feet)	Well Completion	Sample	Recovery	USCS Symbol	Profile	Description	Comments
-216.00	216.0						216'-220' Well Graded clayey-Silty Sand. 60% Fine sand With Coarse to Very Coarse and Gravel throughout. Grain sized up to 3/4". >5 %Clay	
-217.00	217.0							Mud Property (17" Boring) Mud: Density 9.0 lb/ft^3 3% solids 1% sand Filter cake 2/32"
-218.00	218.0			80%	SW-SC			
-219.00	219.0						219' Possible Gravel stringer, quartz sand eith mica.	
-220.00	220.0							Sump: welded stainless. 220' Bottom of Sump
-221.00	221.0						220' to 227 ' backfiller with bentonite chips (tremied)	
-222.00	222.0							
-223.00	223.0							
-224.00	224.0							
-225.00	225.0						225' Same except: With Clay fragments. Multiple thin clay layers from 200' to 225'	
-226.00	226.0							
-227.00	227.0						Total Depth: 227'	

Notes:

1. Mud Property (17" Boring) : Properties measured or observed in drilling mud sampled from well head during reaming of boreole to 17-inches
2. Geophysical logging conducted in 8-inch borehole from ground surface to total depth. Natural Gamma, Caliper, Spontaneous Potential (SP) resistivity (single point, 16-inch and 64 inch normal)
3. Natural Gamma Trend: Visual baseline for natural gamma log over interval of interpreted lithologic zone (e.g. sand, clay, etc).

Top of PVC Casing
Elev. 143.35 ft.

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

GROUND SURFACE

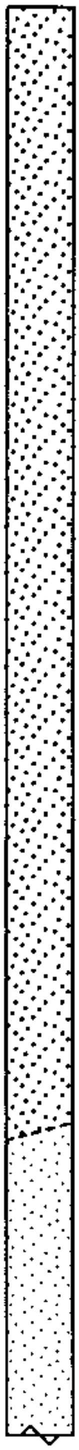
TOP OF CASING at 1.0 ft. above ground surface

11 3/4" DIAMETER BOREHOLE: 0 to 212 ft.

CEMENT/ BENTONITE SEAL: 0 to 164.5 ft.

5" DIAMETER SCHEDULE 80 PVC BLANK CASING: +1.0 to 180 ft.

Depth (ft.)	OVA Reading (ppm)	Description
0		BROWNISH YELLOW WELL GRADED SAND (SW) (10YR 6/6) loose, dry, 90% fine to coarse sand, 10% silt
5		@ 5 ft: color change to dark grayish brown (10YR 4/2), loose, moist
		@ 7 ft: color change to dark yellowish brown (10YR 4/4)
10		@ 10 ft: similar to above
15		@ 15 ft: color change to dark yellowish brown (10YR 6/4)
	0	
20		@ 20 ft: color change to yellowish brown (10YR 5/6), wet
25		@ 25 ft: similar to above
30		
		LIGHT OLIVE BROWN POORLY GRADED SAND (SP) (2.5Y 5/3) medium dense, wet, 90% fine to medium sand, 10% silt
35		@ 35 ft: similar to above
40	0	



FTO

Harding Lawson Associates
Engineering and Environmental Services

Log of Boring and Well Completion MW-OU2-64-180
OU 2 Plume Delineation
Investigation Report
Fort Ord, California

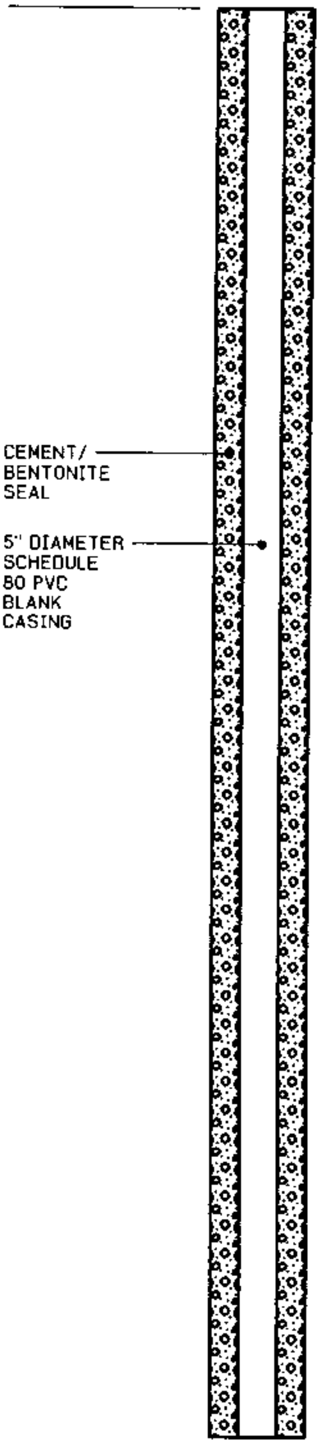
PLATE **1-5**

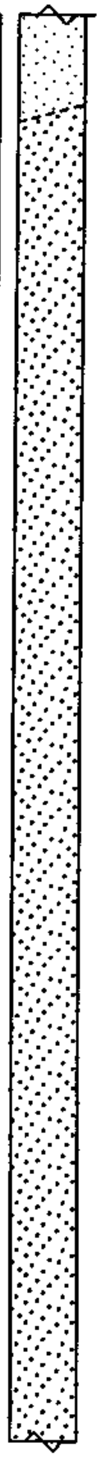
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample





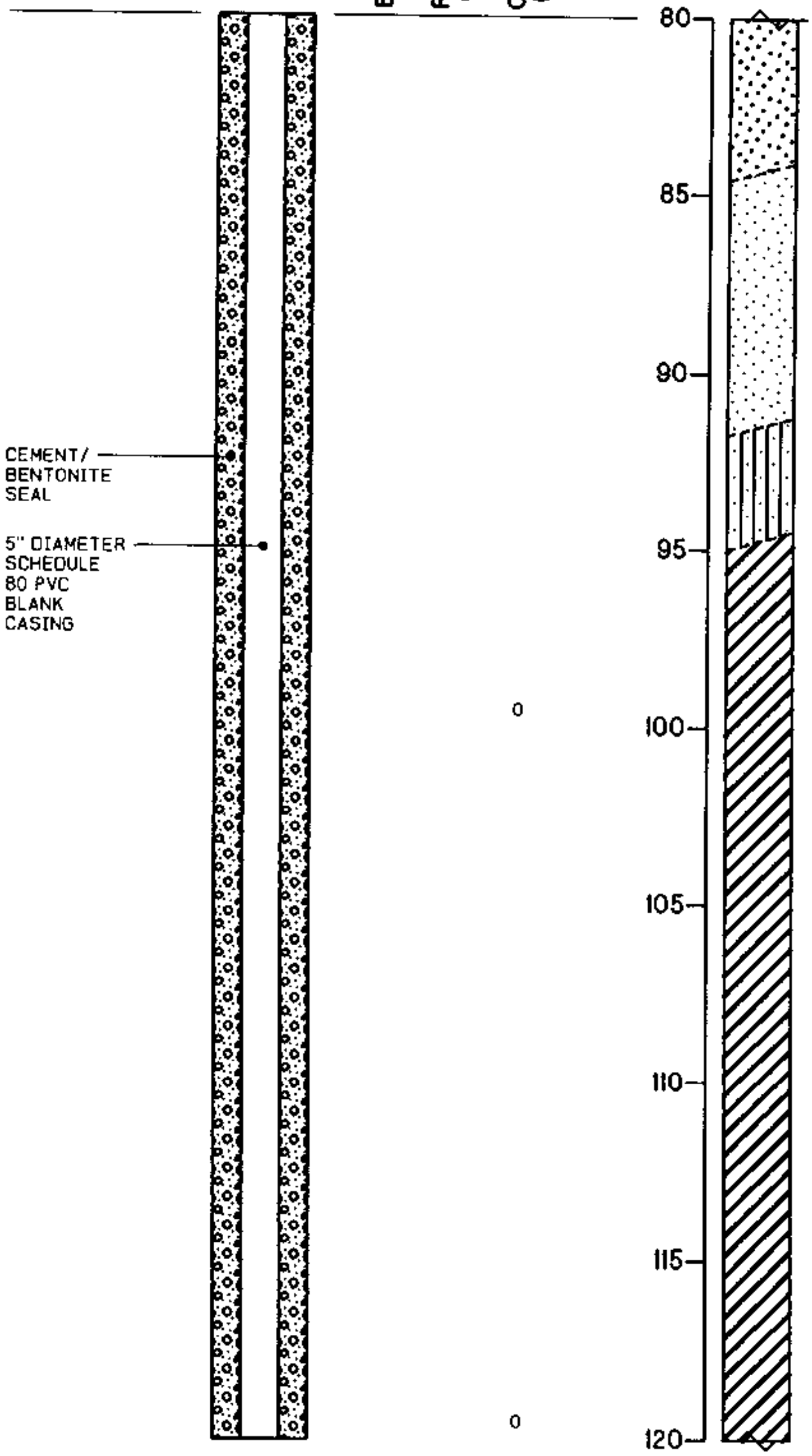
OVA Reading (ppm)	Depth (ft.)	Description
	40	@ 40 ft: similar to above
		LIGHT OLIVE BROWN WELL GRADED SAND (SW) (2.5Y 5/3) medium dense, wet, 90% fine to coarse sand, 10% silt
	45	
	50	@ 50 ft: similar to above
	55	@ 55 ft: similar to above
0	60	@ 60 ft: similar to above
	65	@ 65 ft: similar to above
	70	@ 70 ft: similar to above
	75	@ 75 ft: similar to above, decrease in coarse sand
0	80	

FTO

Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample



@ 80 ft: similar to above

LIGHT OLIVE BROWN POORLY GRADED SAND (SP) (2.5Y 5/3)
medium dense, wet, 90% fine to medium sand, 10% silt

@ 90 ft: similar to above

LIGHT OLIVE BROWN SILTY SAND (SM) (2.5Y 5/3)
medium dense, wet, 60% fine to medium sand, 40% silt

PALE OLIVE SANDY FAT CLAY (CH) (5Y 6/3)
firm, moist, 60% clay, 40% fine sand

@ 97 ft: color change to olive (5Y 5/3), 80% clay, 20% fine sand

@ 100 ft: color change to dark greenish gray (5BG 4/1)

@ 105 ft: similar to above, decrease in fine sand to 10%, trace coarse sand

@ 110 ft: similar to above

@ 115 ft: similar to above, 90% clay, 10% fine sand

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Log of Boring and Well Completion MW-OU2-64-180 PLATE
OU 2 Plume Delineation
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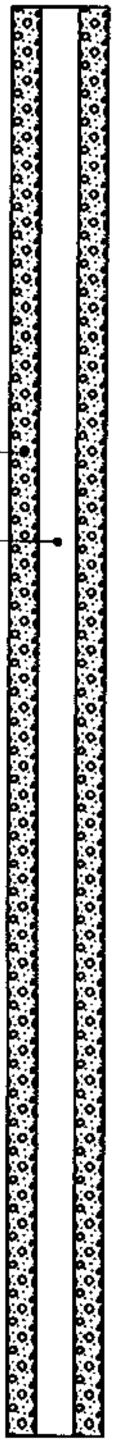
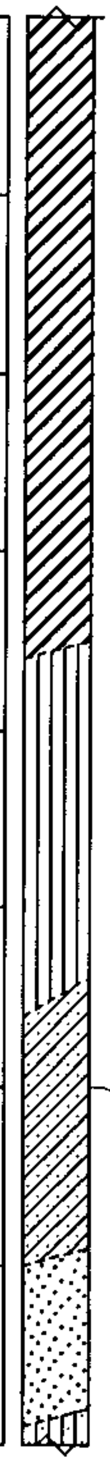
DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
PCB	42481 00123		3/99	

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar Mud Rotary
11 3/4"-diameter
Elevation 140.30 ft. GS Date 02-12-99





OVA Reading (ppm): 0 (at approx. 139 ft); 0 (at approx. 160 ft)

@ 120 ft: similar to above, decrease in sand to 5%

@ 125 ft: color change to olive (5Y 5/3), increase in sand to 10%

@ 130 ft: similar to above

@ 135 ft: similar to above, 80% clay, 20% fine sand

@ 138 ft: Driller notes: drill rods take off, loose drilling
LIGHT OLIVE BROWN SILT (ML) (2.5Y 5/3)
firm, moist, 80% silt, 20% fine sand

@ 145 ft: similar to above

LIGHT OLIVE BROWN CLAYEY SAND (SC) (2.5Y 5/3)
dense, wet, 70% fine to coarse sand, 30% clay
@ 150 ft: similar to above

@ 152 ft: clay decreases to 15%

LIGHT OLIVE BROWN WELL GRADED SAND (SW) (2.5Y 5/3)
dense, wet, 90% fine to coarse sand, 10% silt
Note: lenses of silt and sand from 155 to 160 ft.

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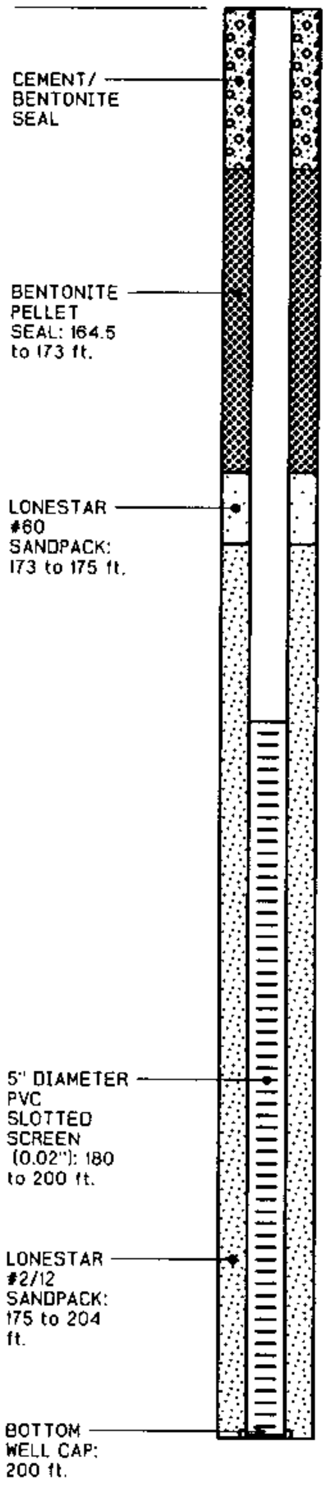
Equipment Speedstar Mud Rotary
11 3/4"-diameter

Elevation 140.30 ft. GS   Date 02-12-99

Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				160		LIGHT OLIVE BROWN SILTY SAND (SM) (2.5Y 5/3) dense, wet, 65% fine to coarse sand, 35% silt
				165		@ 165 ft: similar to above, decrease in silt to 15%
				170		@ 170 ft: similar to above
				175		@ 175 ft: similar to above, 80% fine to coarse sand, 20% silt, trace gravel
		0		180		@ 180 ft: similar to above
				185		@ 185 ft: similar to above, increase in silt to 30%
				190		@ 190 ft: similar to above
				195		@ 195 ft: similar to above
						@ 197 ft: increase in clay and silt, interbedded clay, silt and sand between 197 and 205 ft.
		0		200		



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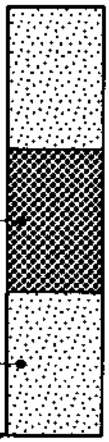
Blows/foot	Recovery (inches)	OVA Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar Mud Rotary
11 3/4"-diameter
Elevation 140.30 ft. GS Date 02-12-99



OVA Reading: 0 (near 219 ft.); 0 (near 239 ft.)

Depth (ft.): 200, 205, 210, 215, 220, 225, 230, 235, 240

@ 200 ft: similar to above

@ 203 ft: similar to above, increase in sand to 35%

LIGHT OLIVE BROWN CLAYEY SAND (SC) (2.5Y 5/3)
dense, wet, 60% fine to coarse sand, 30% fat clay, 10% silt

@ 210 ft: similar to above, 75% fine to coarse sand, 25% silt

@ 212 ft: 80% fine to coarse sand, 20% fat clay
Bottom of boring at 212 ft.
backfilled with #2/10 sand to 208 ft, bentonite pellets to 204 ft.

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Top of PVC Casing
Elev. 144.27

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS Date 02-03-99

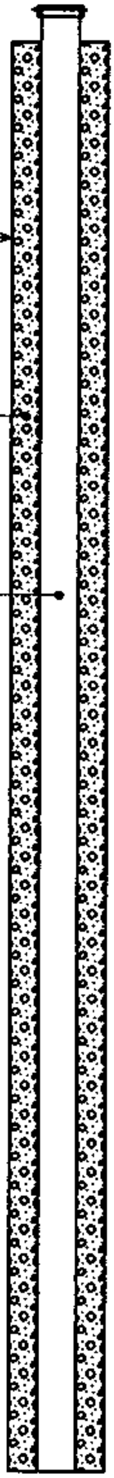
GROUND SURFACE

TOP OF CASING at 1.0 ft. above ground surface

10" DIAMETER BOREHOLE: 0 to 360 ft.

CEMENT/ BENTONITE SEAL: 0 to 308 ft.

5" DIAMETER SCHEDULE 80 PVC BLANK CASING: +1.0 to 318 ft.



OVM Reading (ppm)	Depth (ft.)	Description
	0	DARK YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 4/4) loose, moist, 95% fine sand, 5% silt
		@ 4 ft: color change to 10YR 3/4, 5–10% silt
	5	@ 5 ft: color change to dark yellowish brown (10YR 4/6), 5% silt
		@ 7 ft: change to 5–10% silt/fines, trace moist nodules
	10	
		@ 12 ft: similar to above without nodules
	15	
	20	YELLOWISH BROWN SILTY SAND (SM) (10YR 5/6) medium dense, 80% fine sand, 20% silt
0	25	
0	30	LIGHT YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 6/4) medium dense, 90% fine to very fine sand, 10% silt
0	35	
0	40	YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/6) loose, 95% fine sand, 5% silt

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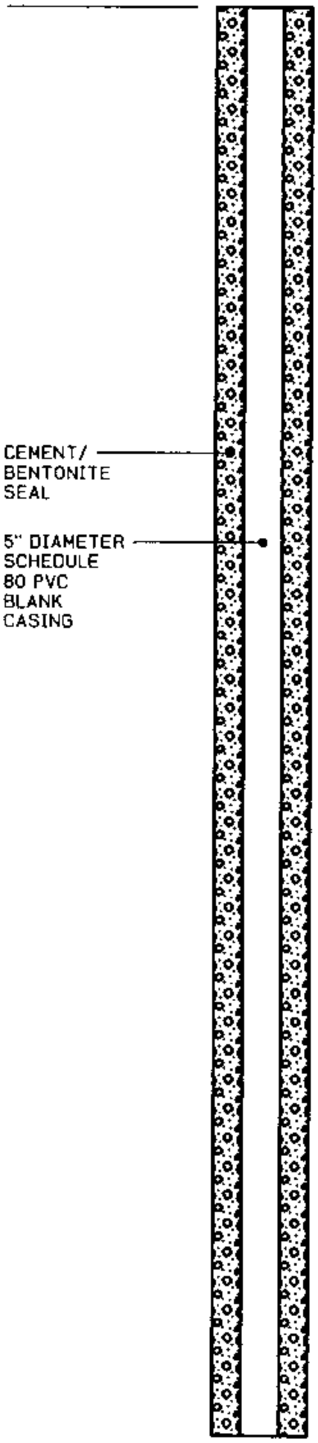
Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS   Date 02-03-99



Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Description
				40	
		0		45	@ 45 ft: similar to above
		0		50	@ 50 ft: similar to above YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/6) medium dense, 90% fine sand, 10% silt
		0		55	
					@ 58 ft: color change to yellowish brown (10YR 5/4)
		0		60	
					@ 64 ft: similar to above
				65	YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/6) medium dense, 90% very fine to fine sand, 10% silt
		0			
		0		70	
		0		75	
		0		80	

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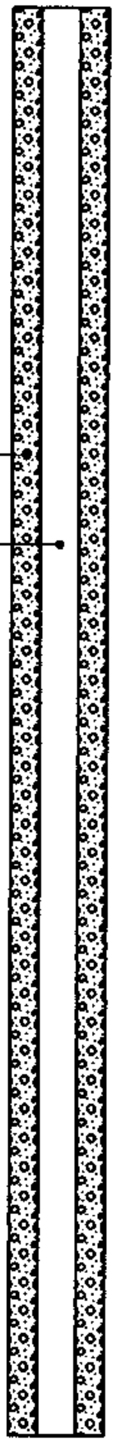
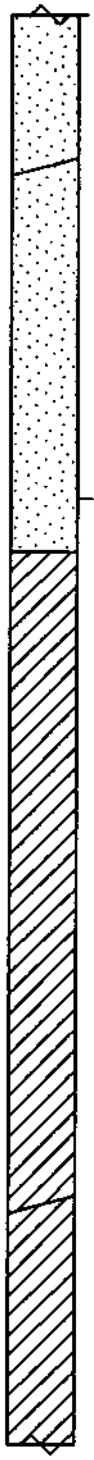
Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS Date 02-03-99



Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample
				80	
		0		85	
		0		90	
		0		95	
		0		100	
		0		105	
		0		110	
		0		115	
		0		120	



@ 80 ft: color change to light olive brown (2.5Y 5/4)

@ 85 ft: color change to dark yellowish brown (10YR 4/6)

@ 92 ft: similar to above, iron oxide mottle throughout

YELLOWISH BROWN POORLY GRADED SAND (SP) (10YR 5/4) medium dense, 90% fine to medium sand, 10% silt

GRAYISH BROWN LEAN CLAY (CL) (2.5Y 5/2) firm to hard, dry to moist, 80-90% clay, 10-20% silt, dry white nodules near top of unit, calcareous

@ 115 ft: color change to dark greenish gray (5G 4/1)

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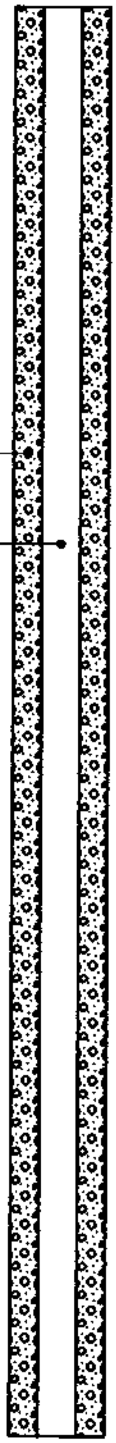
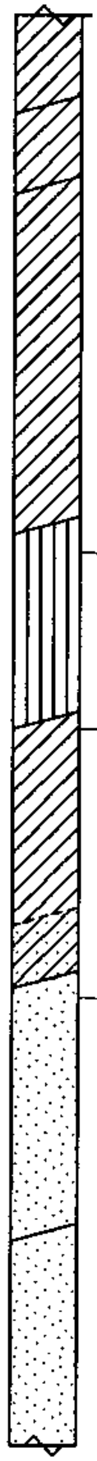
Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample

Equipment Speedstar SS-15 THH
10"-diameter
Elevation 142.30 ft. GS Date 02-03-99





OVM Reading (ppm)	Depth (ft.)
	120
0	125
0	130
0	135
0	140
0	145
0	150
0	155
0	160

@ 120 ft: color change to olive gray (5Y 5/2) mottled color associated with siltier clay

@ 123 ft: color change to dark greenish gray (5G 4/1)

@ 127 ft: color change to olive brown (2.5Y 4/3)

OLIVE SILTY LEAN CLAY (CL)
(5Y 5/3) firm, 70% clay, 30% silt with dry white calcitic nodules

OLIVE BROWN SILT (ML)
(2.5Y 4/3) firm, 80% silt, 20% clay

@ 139 ft: similar to above

LIGHT OLIVE BROWN LEAN CLAY (CL)
(2.5Y 5/3) hard, 90% clay, 10% silt
Geologist Notes: color variation throughout. Iron oxide mottle around relict grains. 3" thick greenish gray stripe, compressional sedimentary features.

LIGHT YELLOWISH BROWN CLAYEY SAND (SC)
(10YR 6/3) medium dense, 60% sand, 40% clay

YELLOWISH BROWN POORLY GRADED SAND (SP)
(10YR 5/6) medium dense, 90% medium sand, 10% silt

BROWNISH YELLOW POORLY GRADED SAND (SP)
(10YR 6/6) medium dense, 95% fine to medium sand, 5% fines

@ 155 ft: color change to brown (10YR 5/3)

@ 159 ft: similar to above

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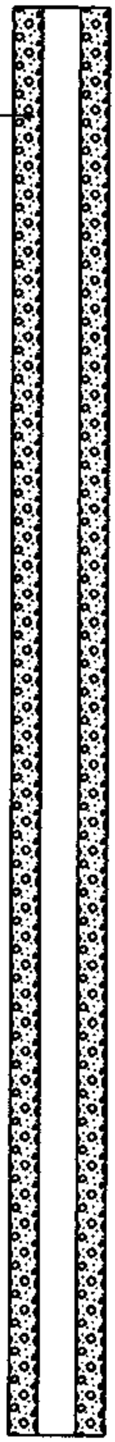
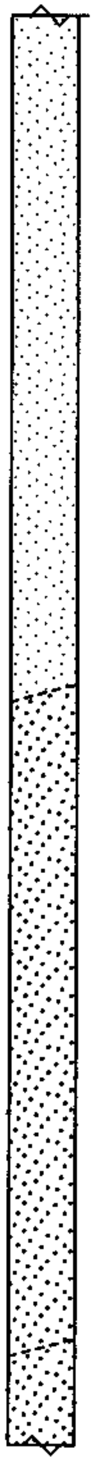
Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS Date 02-03-99

Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				160		
						@ 164 ft: no recovery, cuttings similar to above (>80% sand, <20% fines)
				165		
						@ 169 ft: no recovery, similar to above
				170		
						@ 174 ft: no recovery
				175		
						@ 179 ft: coarser cuttings, no recovery
				180		
						@ 184 ft: no recovery
				185		
						@ 189 ft: limited recovery LIGHT YELLOWISH BROWN WELL GRADED SAND WITH GRAVEL (SW) (10YR 6/4) medium dense, 100% sand, ~15% of grains blue shale - highly weathered
		0		190		
						@ 194 ft: similar to above
		0		195		
						@ 197 ft: 80% sand (tan, iron oxide shale), 20% silty clay, (from cuttings only)
		0		200		

CEMENT/
BENTONITE
SEAL





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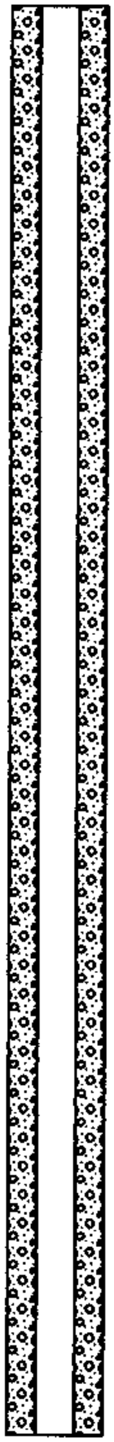
Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS **Date** 02-03-99



Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				200		DARK BROWN WELL GRADED SAND (SW) (7.5YR 4/4) medium dense, 95% sand, 5% silt
				205		@ 204 ft: no recovery, cuttings are light yellowish brown well graded sand (SW) (10YR 6/4) 90% sand, 10% gravel, fines fraction unknown. Some material (20-30% shale) weathered to clay consistency.
		0		210		BROWN SILT (ML) (10YR 5/3) firm, 90% silt, 10% sand, mica rich
		0		215		LIGHT OLIVE BROWN SILT (ML) (2.5Y 5/3) firm, 90% silt, 10% very fine sand
		0		220		LIGHT OLIVE BROWN SILTY SAND (SM) (2.5Y 5/3) firm, 60% fine sand, 30% silt, 10% gravel
		0		225		LIGHT OLIVE BROWN LEAN CLAY WITH SAND (CL) (2.5Y 5/6) hard, 80% clay, 20% sand
		0		230		LIGHT OLIVE BROWN SANDY LEAN CLAY (CL) (2.5Y 5/3) hard, 50% clay, 30% sand, 20% silt Variable drill rate. Laminations of fines within coarser unit
		0		235		LIGHT YELLOWISH BROWN (CLAYEY) SILT (ML) (2.5Y 6/3) very firm, 70% silt, 30% clay LIGHT YELLOWISH BROWN SILTY SAND (SM) (2.5Y 6/3) dense, 70% sand, 20% silt, 10% gravel
		0		240		LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC) (2.5Y 6/3) dense, 40% gravel, 30% sand, 30% clay

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Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample
				240	
		0		245	
		0		250	
				255	
		0		260	
		0		265	
		0		270	
		0		275	
				280	

Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS   Date 02-03-99

LIGHT YELLOWISH BROWN SILTY SAND WITH GRAVEL (SM)
(2.5Y 6/3) dense, 50% sand, 30% gravel, 20% silt

LIGHT YELLOWISH BROWN SANDY LEAN CLAY (CL)
(2.5Y 6/3) hard, 70% clay, 30% sand

@ 254 ft: no recovery (rock in shoe), cuttings are light yellowish brown clayey sand, (SC)
(2.5Y 6/3) 80% well graded sand, 20% clay

LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (SC)
(2.5Y 6/3) 50% sand, 30% gravel, 20% clay

LIGHT YELLOWISH BROWN CLAYEY GRAVEL (GC)
(2.5Y 6/3) dense, 60-70% gravel, 20-30% clay, 10% sand, (rocks with clay matrix)

LIGHT YELLOWISH BROWN SILTY GRAVEL (GM)
(2.5Y 6/3) dense, 60% gravel, 20% sand, 20% silt, (rocks with silt matrix)
diatomaceous nodules to 1.5 inches long

LIGHT OLIVE BROWN CLAYEY GRAVEL WITH SAND (GC)
(2.5Y 5/3) dense, 50% gravel, 30% clay, 20% sand

@ 275 ft: drill chatters in coarser material

@ 279 ft: no recovery

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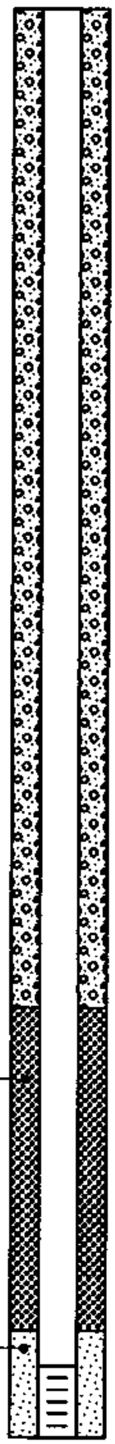
Equipment Speedstar SS-15 THH
10"-diameter

Elevation 142.30 ft. GS **Date** 02-03-99



Blows/foot	Recovery (inches)	OVM Reading (ppm)	Sample Number	Depth (ft.)	Sample	Description
				280		cuttings: ~70% gray sand, ~30% blue clay
		0		285		@ 284 ft: similar to above
						cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (GC) (2.5Y 6/3) dense, 60% sand, 20% clay, 20% gravel
				290		@ 289 ft: no recovery
		0		295		LIGHT YELLOWISH BROWN CLAYEY GRAVEL (GC) (2.5Y 6/3) dense, 50% gravel, 40% clay, 10% sand
		0		300		cuttings: LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC) (2.5Y 6/3) 50% gravel, 30% sand, 20% clay
		0		305		cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (GC) (2.5Y 6/3) 50% sand, 30% gravel, 20% clay
		0		310		cuttings: LIGHT YELLOWISH BROWN CLAYEY GRAVEL WITH SAND (GC) (2.5Y 6/3) dense, 50% gravel, 30% clay, 20% sand
		0		315		cuttings: LIGHT YELLOWISH BROWN CLAYEY SAND WITH GRAVEL (SC) (2.5Y 6/3) dense, 50% sand, 30% gravel, 20% clay
		0		320		cuttings: multi-colored well graded gravel with sand (GW) dense, 60-70% gravel, 20-30% sand, 10% fines

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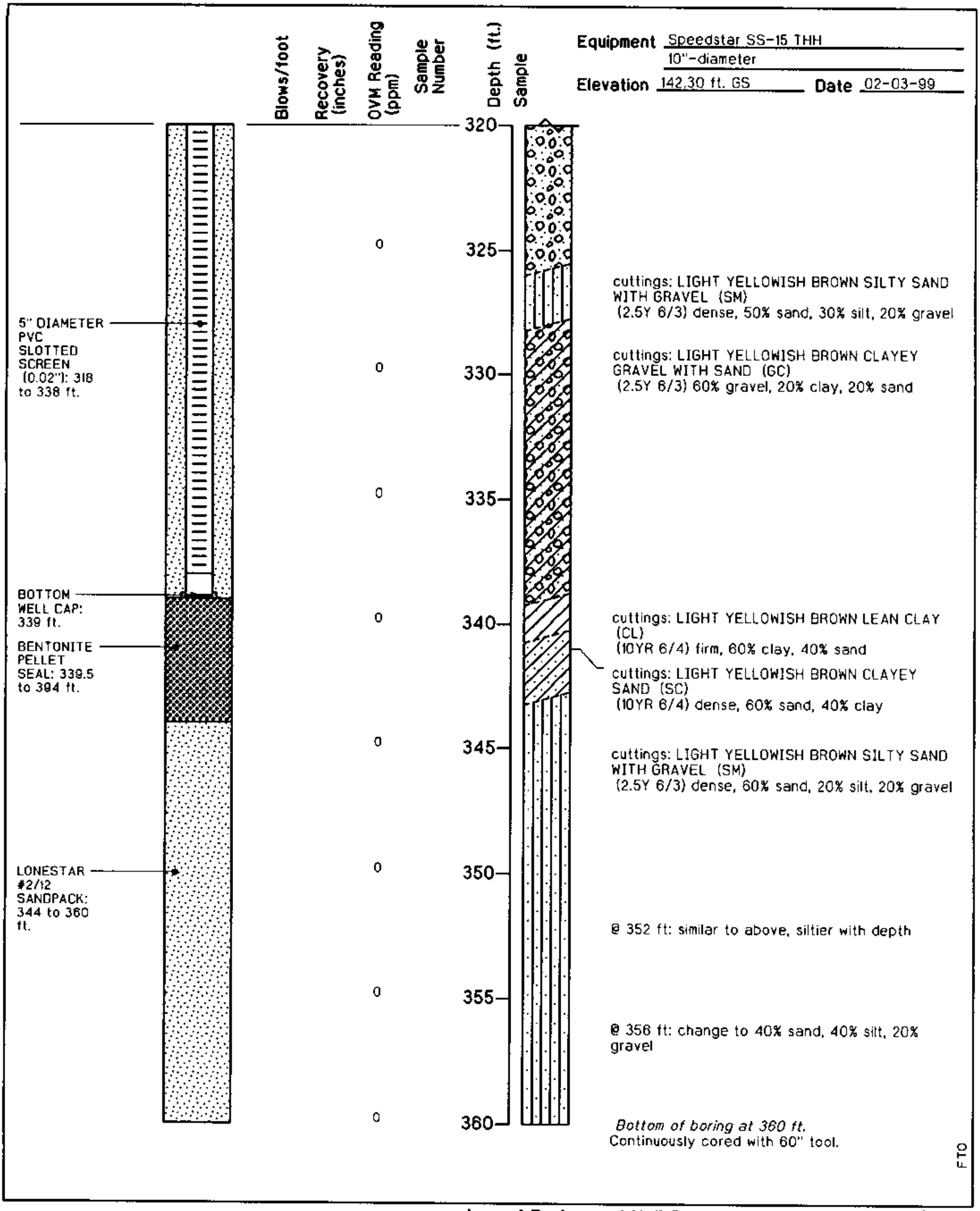

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Attachment B:

Groundwater Capture Model

Attachment B. Groundwater Capture Model

Figures:

B1. Simulation 2A – Fort Ord Steady State Model Simulated Groundwater Capture – OU2 (Upper 180-Aquifer) Quarter 1 2022

B2. Simulation 2A-30 – Fort Ord Steady State Model Simulated Groundwater Capture – OU2 (Upper 180-Aquifer) Quarter 1 2022

B3. Simulation 2B – Fort Ord Steady State Model Simulated Groundwater Capture – OU2 (Upper 180-Aquifer) Quarter 3 2022

B4. Simulation 2B-30 – Fort Ord Steady State Model Simulated Groundwater Capture – OU2 (Upper 180-Aquifer) Quarter 3 2022.

Groundwater modeling shows extraction well EW-OU2-09-180 only partially captures the carbon tetrachloride plumes in the Upper 180-Foot Aquifer, and this partial capture may also only be seasonal due to changes in groundwater flow induced by downgradient agricultural supply wells. The simulated capture zone appears wide enough to encapsulate the southern part of the carbon tetrachloride plume located upgradient of EW-OU2-09-180, but the average annual flow direction may be somewhat offset from the long axis of the carbon tetrachloride plume in this area and the downgradient portion of the plume, located east of EW-OU2-09-180 and adjacent to the discontinuity in the Intermediate 180-Foot Aquitard, is not being captured (Ahtna, 2023).

To capture the downgradient carbon tetrachloride plume in the Upper 180-Foot Aquifer before it enters the Lower 180-Foot Aquifer, an additional extraction well (EW-OU2-13-180) will be installed with a screened interval within the Upper 180-Foot Aquifer in the vicinity of monitoring wells MW-OU2-64-180 and MW-OU2-66-180 (Figure 7). This well will be connected by conveyance piping to the Operable Unit 2 (OU2) groundwater treatment plant (GWTP) for groundwater treatment. Minor adjustment will be required in the operation of the OU2 GWTP to incorporate control of extraction well EW-OU2-13-180 and to balance flowrates from EW-OU2-13-180 with existing extraction flowrates.

Groundwater flow and transport simulations were developed to determine the location and design flowrate for the proposed extraction well using the basewide numerical groundwater flow model (the “model”), which is used to simulate groundwater conditions beneath the former Fort Ord. The model was updated in January 2016 (USACE-HEC, 2016) to evaluate hydraulic capture of COCs by the A-Aquifer and Upper 180-Foot Aquifer extraction wells. The model was updated in 2017 to extend the model domain 400 feet vertically and 1,000 feet horizontally to the south. The model was further updated in 2018 to include a “wave-cut terrace” conceptualization to assist in the simulation of observed sharp drops in water levels in the A-Aquifer. Additionally, the number of homogeneous hydraulic conductivity zones was reduced based on limited field data and the concept of appropriate complexity. In the 2022 model update, several boundary conditions (recharge, river boundary, ocean boundary, etc.) were updated based on available data. The number of wells used for calibration was increased to include all applicable monitoring well data. This includes wells in the A-Aquifer, Upper and Lower 180-Foot Aquifers, and the 400-Foot Aquifer. Hydraulic conductivity values in geologic units were adjusted using both manual and automated parameter estimation techniques to obtain a reasonable model calibration.

Additionally, pilot points were used in the A-Aquifer to capture the special variation of hydraulic conductivity in that model layer.

The model simulates backward-tracking groundwater flow paths induced by operation of extraction wells. The simulation was run using the first quarter of 2022 (average period) calibration parameters (Simulation 2a) and the third quarter of 2022 (dry period) calibration parameters (Simulation 2b). Additional simulations assuming a flowrate of 30 gpm were also performed using the first quarter of 2022 (average period) calibration parameters (Simulation 2a30) and the third quarter of 2022 (dry period) calibration parameters (Simulation 2b30). The details of the latest groundwater modeling effort in 2023 are presented in this Attachment B and summarized below. The model will be refined and some adjustments may be made to the final system design, construction, and operation as data are collected from well installation and testing activities.

The remedial design modeling effort included a baseline particle-tracking simulation using the existing regional groundwater flow and transport model to evaluate the current groundwater flow regime. The simulation indicated that the addition of extraction well EW-OU2-13-180 will enhance capture of the carbon tetrachloride plumes in the Upper 180-Foot Aquifer. However, the variations in the regional groundwater flow patterns during the dryer calibration period indicate that the extent of capture may be variable due to changes in recharge and regional pumping. These model results are consistent with historical data collected in the field and the current understanding of OUCTP migration.

The proposed location for new extraction well EW-OU2-13-180 is approximately 841 feet east of extraction well EW-OU2-09-180 at the upgradient edge of the discontinuity in the Intermediate 180-Foot Aquitard (Figure 7). This location is in the vicinity of MW-OU2-64-180 where some of the highest carbon tetrachloride concentrations have been measured recently. Placement of the well in this area is expected to remove most of the carbon tetrachloride mass in the plume before it can migrate downward into the Lower 180-Foot Aquifer. Four model scenarios were developed to simulate groundwater plume capture under potential conditions within the new extraction well area. The model scenarios were developed to evaluate potential design and operating parameters based on previously observed site conditions.

The four scenarios include:

Scenario 1: New extraction well EW-OU2-13-180 with:

a. Pumping at a flowrate of 60 gpm (based on performance of nearby extraction wells EW-OU2-08-180 and EW-OU2-09-180)

b. Calibration parameters developed from evaluating available data for the first quarter of 2022 (average period)

Scenario 2: New extraction well EW-OU2-13-180 with:

a. Pumping at a flowrate of 30 gpm

b. Calibration parameters developed from evaluating available data for the first quarter of 2022 (average period)

Scenario 3: New extraction well EW-OU2-13-180 with:

a. Pumping at a flowrate of 60 gpm

b. Calibration parameters developed from evaluating available data for the third quarter of 2022 (dry period)

Scenario 4: New extraction well EW-OU2-13-180 with:

a. Pumping at a flowrate of 30 gpm

b. Calibration parameters developed from evaluating available data for the third quarter of 2022 (dry period)

Scenario 1: Groundwater modeling indicates that an additional extraction well pumping at 60 gpm would remove most of the mass of carbon tetrachloride from the Upper 180-Foot Aquifer that is not captured by extraction well EW-OU2-09-180 and intercept the carbon tetrachloride before it could migrate downward to the Lower 180-Foot Aquifer. The modeled simulations also indicated that the capture zone of this well would also encompass most of the current plume extent east of extraction well EW-OU2-09-180 and a portion of the current plume extent northwest of extraction well EW-OU2-09-180 during the average period (Figure B1).

Scenario 2: This scenario assumes the flowrate for new extraction well EW-OU2-13-180 is 30 gpm due to limitations in OU2 GWTS capacities (e.g., pipeline back pressure due to operation of EW-OU2-09-180), the aquifer itself, or other factors. Groundwater modeling results are similar to Scenario 1, indicating the additional extraction well pumping at a reduced flow rate during the average period will still be effective in removing the mass of carbon tetrachloride from the Upper 180-Foot Aquifer and preventing carbon tetrachloride mass from entering the Lower 180-Foot Aquifer (Figure B2).

Scenario 3: This scenario assumes the flowrate for new extraction well EW-OU2-13-180 is 60 gpm. Groundwater modeling results indicate a reduced capture area for the southern carbon tetrachloride plume in the Upper 180-Foot Aquifer and no capture of the northern carbon tetrachloride plume in the Upper 180-Foot Aquifer during the dry period; however, continued operation new extraction well EWOU2-13-180 will still remove carbon tetrachloride mass before it could migrate downward to the Lower 180-Foot Aquifer (Figure B3).

Scenario 4: This scenario assumes the flowrate for new extraction well EW-OU2-13-180 is 30 gpm due to limitations in OU2 GWTS capacities (e.g., pipeline back pressure due to operation of EW-OU2-09-180), the aquifer itself, or other factors. Groundwater modeling results are similar to Scenario 3, but new extraction well EW-OU2-13-180 operating at 30 gpm captures a smaller plume area and may not be as effective at preventing downward migration of the OUCTP to the Lower 180-Foot Aquifer (Figure B4).

The groundwater modeling results indicate the operational flowrate for new extraction well EW-OU2-13-180 should be 60 gpm or greater to most effectively capture the OUCTP in the Upper 180-Foot Aquifer and prevent migration of carbon tetrachloride to the Lower 180-Foot Aquifer. The modeling results also indicate lower flowrates will still effectively remove carbon tetrachloride mass before it can migrate to the Lower 180-Foot Aquifer.

The modeling results also indicate new extraction well EW-OU2-13-180 either only partially captures the northern carbon tetrachloride plume during the average period or does not capture the northern carbon tetrachloride plume during the dry period. However, data for OUCTP in the Upper 180-Foot Aquifer indicate the northern carbon tetrachloride plume is attenuating and will likely migrate into the capture area of new extraction well EW-OU2-13-180 at it moves toward the discontinuity in the Intermediate 180-Foot Aquitard (Ahtna, 2023). Therefore, analysis of whether additional actions are necessary to address the northern carbon tetrachloride plume will be conducted after implementation of additional groundwater extraction to improve hydraulic control and containment of the OUCTP in the Upper 180Foot Aquifer before it can migrate to the Lower 180-Foot Aquifer.

The final design and construction of the groundwater extraction and treatment system will depend on field and aquifer conditions encountered during the well installation and testing activities. The implementation strategy for the remedial action will include provisions for adapting the system design as required (e.g., an alternating pumping strategy or optimized flow rates for operating extraction wells in the Bunker Hill network). Remedial action implementation will proceed as sequential activities that will include sufficient flexibility for site professionals to respond to field conditions. The hydraulic properties of the Upper 180-Foot Aquifer within the proposed extraction area and the ability of extraction well EW-OU2-13-180 to produce water will determine the final configuration of the system. The design and operation of the extraction and conveyance system will depend on extraction rates.

The proposed sequence of implementation is as follows:

1. Installation of extraction well EW-OU2-13-180 with a screen interval based on the lithologic sequence encountered.

2. Well development and specific capacity testing to maximize and test well production.

3. Hydrogeologic testing to refine aquifer parameters for additional design.

4. Refinement of the groundwater model (if required).

5. Evaluation of the current design and making adjustments, as necessary, in planned GWTS operations.

6. Redesigning the system only if remediation cannot be achieved as specified in this RD Addendum.

The implementation of the remedial action will proceed through the sequence discussed above to the extent required to install and operate the groundwater extraction and treatment system. The steps required are dependent on each previous step. If installation of the one additional extraction well provides sufficient quantity of water and yields the desired effects upon the aquifer, no further well performance testing work will be required, and the remainder of the system will be installed as specified. If testing results indicate installation of the one additional extraction well cannot achieve remediation goals per this RD Addendum, further well-performance testing work may be conducted to collect additional data to support system redesign.

References:

Ahtna, 2023. *Final Operable Unit Carbon Tetrachloride Plume, Fourth Quarter 2021 through Third Quarter 2022 Groundwater Monitoring Report, Former Fort Ord, California*. September. AR# OUCTP-0105B.

U.S. Army Corps of Engineers (USACE) – Hydrological Engineering Center (HEC) (Jon Fenske), 2016, “Fort Ord Groundwater Flow Model – Jan 2016 Model Update”, 9 p.

Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 (average period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 60 gpm

Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2a- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 1 2022

Figure B1

April 2023

Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 1 (average period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 30 gpm

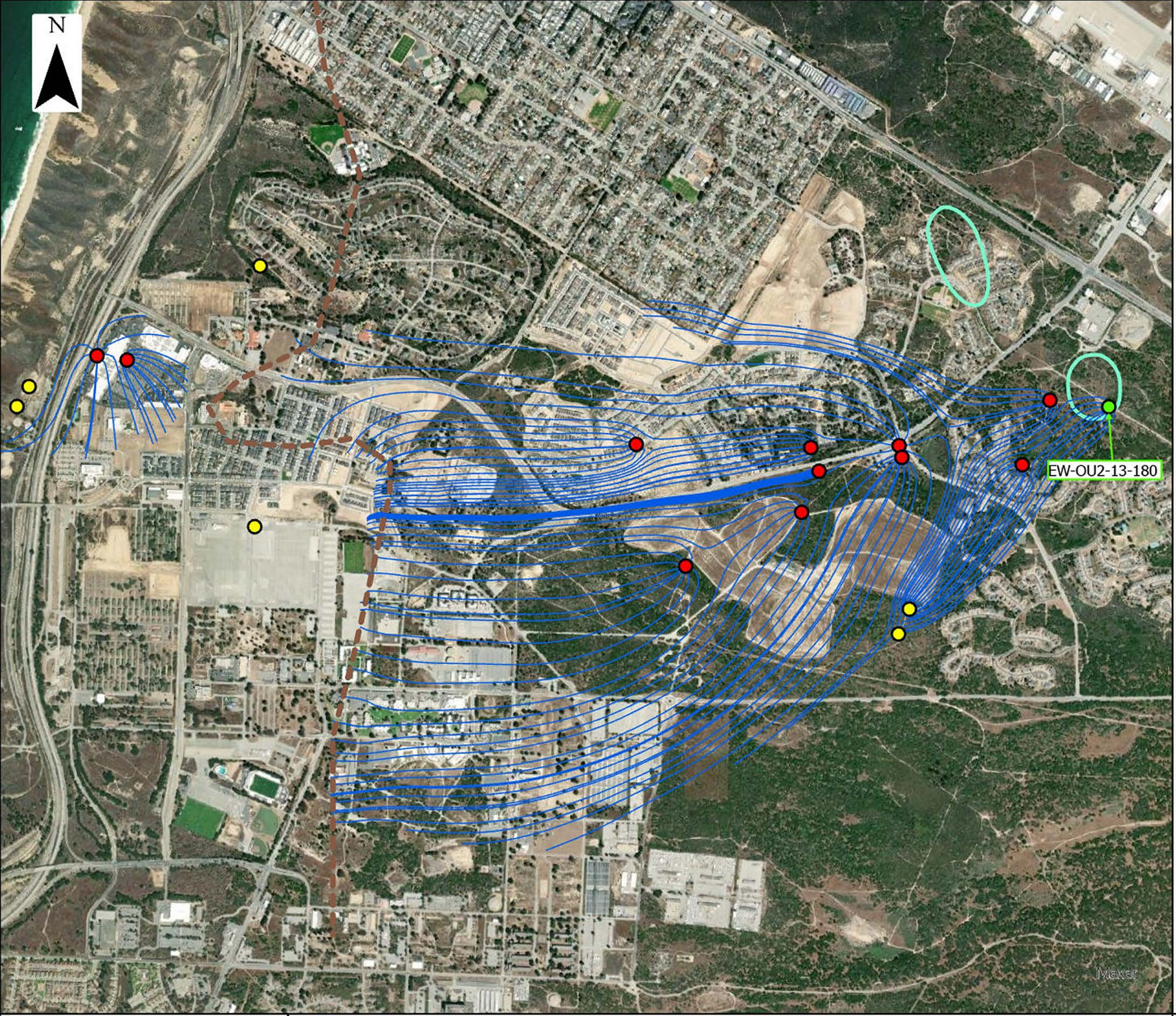
Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2a_30- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 1 2022

Figure B2

April 2023



Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 (dry period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 60 gpm

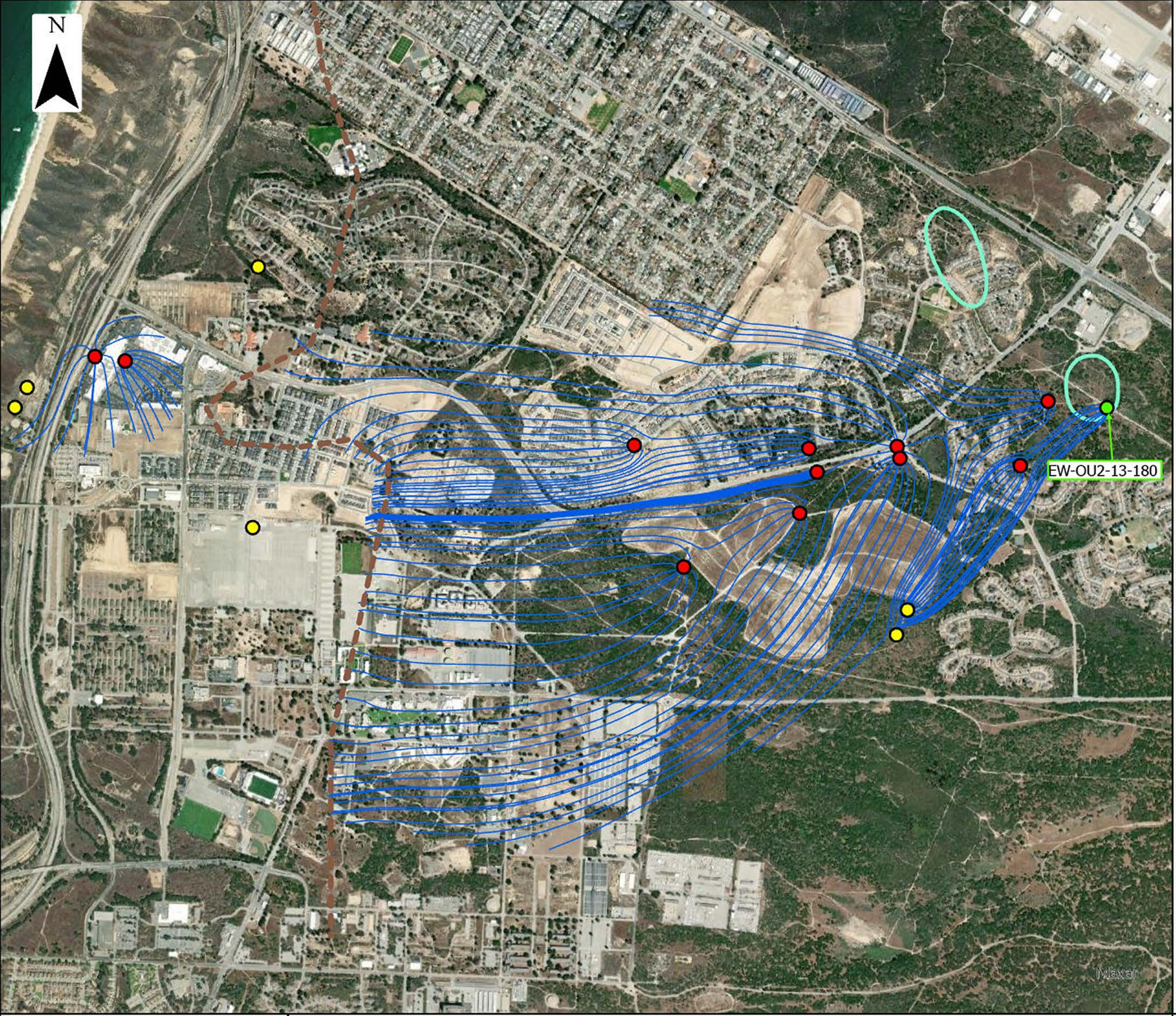
Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2b- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 3 2022

Figure B3

April 2023



Legend

- Particle Track Path Lines
- Proposed Upper 180ft Aquifer Well
- Extraction Well Upper 180-Aquifer
- Injection/Infiltration Well Upper 180-Aquifer
- Approx. End of Salinas Valley Aquitard (SVA)
- CT

Notes:

Simulation based on the Steady State simulated heads for Quarter 3 (dry period) of 2022 with the addition of one new Upper 180-Aquifer well pumping at 30 gpm

Particle Pathways represent backwards tracking for 15 years (or until particles reach the SVA outcrop)

Background imagery: World Imagery from ArcGIS Pro

SIMULATION 2b_30- Fort Ord Steady State Model Simulated Groundwater Capture - OU2 (Upper 180-Aquifer) Quarter 3 2022

Figure B4

April 2023

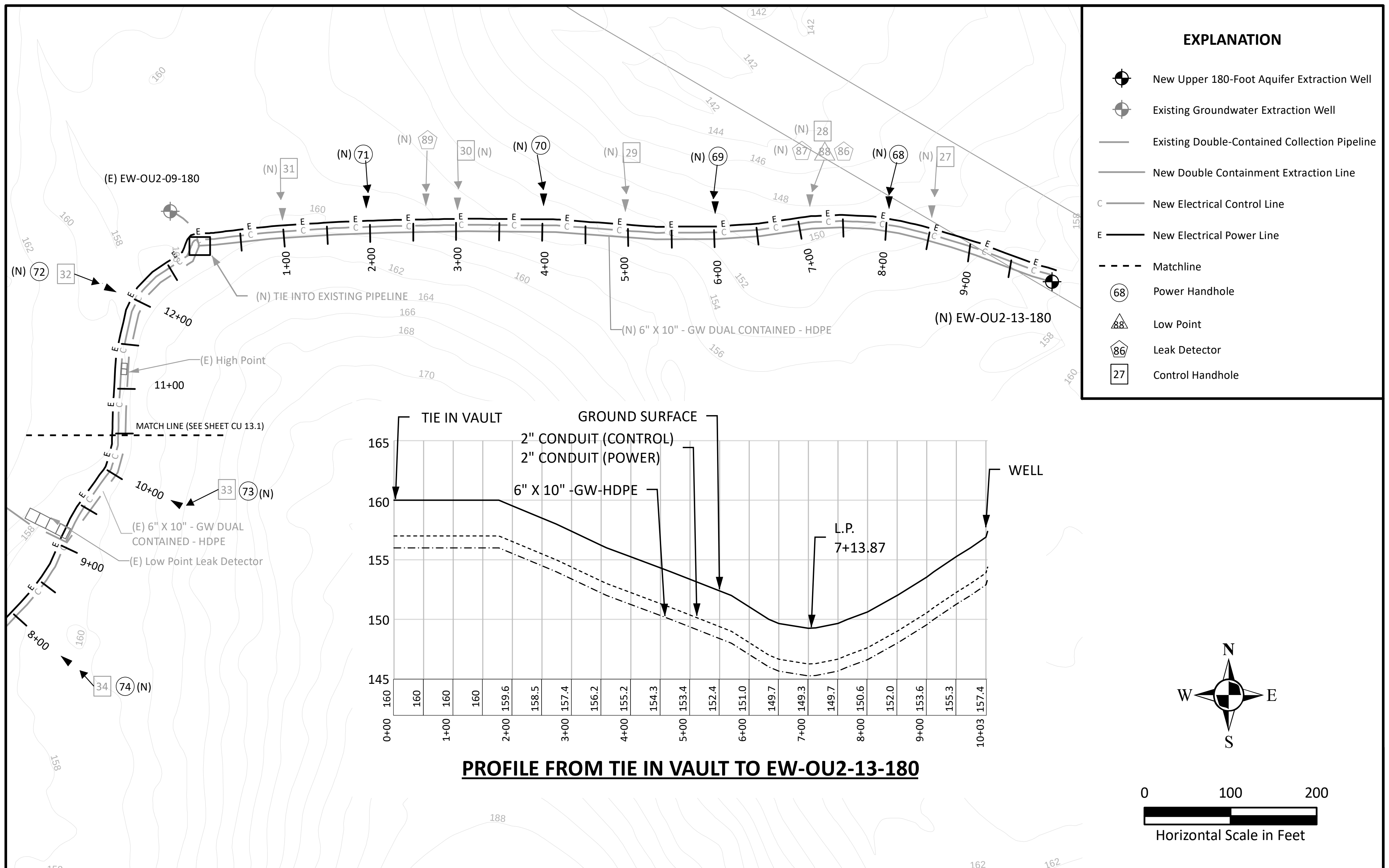
Attachment C:

Construction Drawings[7]

[7] The actual design and construction of EW-OU2-13-180 and associated equipment are subject to modification from this QAPP based on field conditions and will be described as QAPP deviations in the Completion Report.

UPPER 180-FOOT AQUIFER REMEDIAL DESIGN
CONSTRUCTION DESIGN PLAN

FORMER FORT ORD, CALIFORNIA



INSTRUMENTATION DRAWING INDEX

FORT ORD, CA

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
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DESIGNED:
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SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
CONSTRUCTION DRAWING
COVER SHEET

SCALE NONE
DRAWING NUMBER CU1
SHEET NUMBER 1 OF 13

SINGLE LINE LEGEND:

- NORMALLY OPEN RELAY CONTACT
- NORMALLY CLOSED RELAY CONTACT
- GROUND CONNECTION
- PRESSURE SWITCH OPEN ON INCREASE
- NORMALLY CLOSED FLOAT SWITCH
- SINGLE BREAK SWITCH
- NORMALLY OPEN MOMENTARY PUSH BUTTON
- NORMALLY CLOSED MOMENTARY PUSH BUTTON
- TWO POSITION CONTACT
- THERMAL OVERLOAD DEVICE
- 5 HP — THREE PHASE MOTOR WITH 5HP
- EMP — ELECTRONIC METERING AND PROTECTION PANEL
- R — CONTROL RELAY
- PLC PANEL
- FUSE WITH RATING
- DRAW-OUT BREAKER 4,000A FRAME 4,000A TRIP
- TRANSFORMER W/GROUNDED SECONDARY – KVA, SIZE AND VOLTAGE RATIO AS NOTED
- IR — CURRENT TRANSFORMER
- M — CURRENT SENSING RELAY
- METER
- CONTROL POWER TRANSFORMER
- "Y" TRANSFORMER, CENTER GROUNDED
- DELTA TRANSFORMER
- EQUIPMENT DISCONNECT
- MOTOR STARTER (COORDINATE WITH MECHANICAL FOR CONTROL)
- TRANSFORMER (MOUNTED ON THE PAD)
- EQUIPMENT ENCLOSURE
- PANEL MOUNTED GROUND BUS BAR
- GROUND ROD
- UFER GROUND
- GROUNDED WATER PIPE
- COMMUNICATION GROUND BAR

400 A
3P LSIG

CIRCUIT BREAKER 400 AMPERE, 3 POLE
L CIRCUIT PROTECTION AGAINST OVERLOAD WITH LONG INVERSE TIME DELAY TRIP
S CIRCUIT PROTECTION AGAINST OVERLOAD WITH SHORT INVERSE OR DEFINITE TIME DELAY TRIP
I CIRCUIT PROTECTION AGAINST INSTANTANEOUS SHORT CIRCUIT ADJUSTABLE TRIP
G CIRCUIT PROTECTION AGAINST EARTH FAULTS

MOLDED CASE CIRCUIT BREAKER

ABBREVIATIONS:

1HA	480/277V PANEL (# INDICATES FLOOR)
1LA	120/208V PANEL (# INDICATES FLOOR)
A	AMPERES
AC	AIR CONDITIONING UNIT
AFF	ABOVE FINISHED FLOOR
AHU	AIR HANDLING UNIT
AWG	AMERICAN WIRE GAUGE
C	CONDUIT
CB	CIRCUIT BREAKERS
CH	CHILLER
CHW	CIRCULATING PUMP HOT WATER
DWG	DRAWING
(E)	EXISTING
IAC	INTERRUPTABLE ALLOWABLE CURRENT
EF	EXHAUST FAN
ES	EMERGENCY SHOWER
EWH	ELECTRIC WATER HEATER
EWS	EYE WASH STATION
FC	FIRE CONTROL
FSCP	FIRE SPRINKLER CONTROL PANEL
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
GW	GROUND WIRE
H	INFRARED HEATER
HDPE	HIGH-DENSITY POLYETHYLENE
HF	HARMONIC FILTER
HOA	HAND-OFF-AUTO SWITCH
HP	HORSE POWER
HZ	HERTZ
IAC	INTERRUPTABLE ALLOWABLE CURRENT
IDC	INDICATOR CONTROL SWITCH
ISH	INDICATOR SWITCH HIGH
J	JUNCTION BOX
LSH	LEVEL SWITCH HIGH
MSB	MAIN SWITCH BOARD
MTG	MOUNTING
(N)	NEW
(O)	OHM CURRENT RESISTANCE IN OHMS
P	PRIMARY CONDUIT
PDSH	PRESSURE DIFFERENTIAL SWITCH HIGH
PH,ø	PHASE
PLC	PROGRAMMABLE LOGIC CONTROLLER
PNL	PANEL
PR	PAIR
PSH	PRESSURE SWITCH HIGH
(RE)	REMOVE
S	SPARE CONDUIT
SHT	SHEET
SPS	SAFETY PRESSURE SWITCH
SUB	SUBSTATION
SW	SWITCH
SWF	SINE WAVE FILTER
TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR
TYP	TYPICAL
V	VOLTS
VFD	VARIABLE FREQUENCY DRIVE
W	WATTS
W/A	WATTS/AMPS
WP	WATER PROOF
XFRM	TRANSFORMER

GENERAL NOTES:

1. ALL ELECTRICAL WORK SHALL BE PERFORMED IN ACCORDANCE WITH THE LATEST NATIONAL ELECTRICAL CODE (NEC), NFPA, IEEE AND APPLICABLE U.S. ARMY REGULATIONS.
2. THE ELECTRICAL INSTALLATION SHALL BE GROUNDED IN ACCORDANCE WITH ARTICLE 250 OF THE NEC.
3. MOUNTING HEIGHTS ABOVE FINISHED FLOOR ARE AS INDICATED BELOW UNLESS OTHERWISE NOTED ON THE DRAWINGS:

PANELBOARD	72" TO TOP OF PANELBOARD
WALL TOGGLE SWITCH	48" TO CENTER OF COVER PLATE
RECEPTACLE	12" TO CENTER OF COVER PLATE
MOTOR STARTER	60" TO CENTER OF COVER PLATE

4. ALL POWER PANELBOARDS AND COMMUNICATIONS CABINETS SHALL BE PROVIDED WITH GROUNDING SYSTEMS PER NEC ARTICLE 250.
5. MINIMUM SIZE CONDUIT/CONDUCTORS IS 3/4" W/ (2) #12ga+12ga GROUND.
6. ALL VDF'S SHALL BE PROVIDED WITH LINE SIDE FILTER AND MANUAL BYPASS SWITCH.

COMMUNICATION LEGEND

- DATACOMM RECEPTACLE
- TELEPHONE/DATA RECEPTACLE
- CCTV INTERNET PROTOCOL (IP) ADDRESSABLE FIXED CAMERA (RATED FOR THE ENVIRONMENT)

TELECOMMUNICATION & CONTROL CONDUIT LEGEND

- CLOSED CIRCUIT TV
- EXISTING TELEPHONE AERIAL
- NEW TELEPHONE AERIAL
- NEW TELEPHONE UNDERGROUND
- CONDUIT TURNING UP
- CONDUIT TURNING DOWN
- NEW CONTROL CONDUIT UNDERGROUND

ELECTRICAL CONDUIT LEGEND

- EXISTING ELECTRICAL AERIAL
- NEW ELECTRICAL AERIAL
- NEW ELECTRICAL UNDERGROUND

LEGEND:

- "*" — WALL MOUNTED FIXTURE (SUITABLE FOR OUTDOOR) (* REPRESENT TYPE OF FIXTURE; SEE LIGHTING SCHEDULE)
- 2x4 LIGHT FIXTURE
- 2x4 LIGHT FIXTURE WITH BATTERY
- 1x4 LIGHT FIXTURE
- 1x4 LIGHT FIXTURE WITH BATTERY
- FLUORESCENT STRIP LINEAR FIXTURE (SUSPENDED)
- FLUORESCENT STRIP LINEAR FIXTURE (WALL MOUNTED)
- FLUORESCENT STRIP LINEAR FIXTURE (SUSPENDED) EMERGENCY ILLUMINATION
- EMERGENCY LIGHT, BATTERY POWERED
- RECESSED DOWNLIGHT IN HARDLID CEILING
- WALL MOUNTED EXIT SIGN – SINGLE FACE
- POLE MOUNTED FIXTURE (SUITABLE FOR OUTDOORS)
- SURFACE MOUNTED ELECTRICAL PANEL
- FLUSH MOUNTED PANEL BOARD
- $a — SINGLE POLE SWITCH (20A, 120V) ("a" DENOTES LCP CHANNEL)
- RP — 4 SQ. MM. METAL JUNCTION BOX. LEADER REPRESENT CIRCUIT DESIGNATION (TYP)
- WALL MOUNTED JUNCTION BOX
- RP — 20A, 120V DUPLEX RECEPTACLE. LEADER REPRESENT CIRCUIT DESIGNATION (TYP)
- +42" — 20A, 120V GFCI RECEPTACLE. (+42" INDICATES MOUNTING HEIGHT)
- 20A, 120V QUAD RECEPTACLE
- WALL MOUNTED PHOTO CELL (SUITABLE FOR OUTDOORS)
- OC — TRAFFIC RATED HANDHOLE
- DULL TECHNOLOGY OCCUPANCY SENSOR
- UTILITY POLE
- R — THREE PHASE MOTOR
- 20A, SINGLE POLE RELAY, VOLTAGE AS NOTED
- 21 — HAND HOLD
- HAND HOLD NUMBER
- EF 1 — MECHANICAL EQUIPMENT (REFER TO MECHANICAL DRAWINGS FOR EXACT LOCATION AND DETAILS) LEADER REPRESENT CIRCUIT DESIGNATION (TYP)

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(IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: HR
CHECKED: HR

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

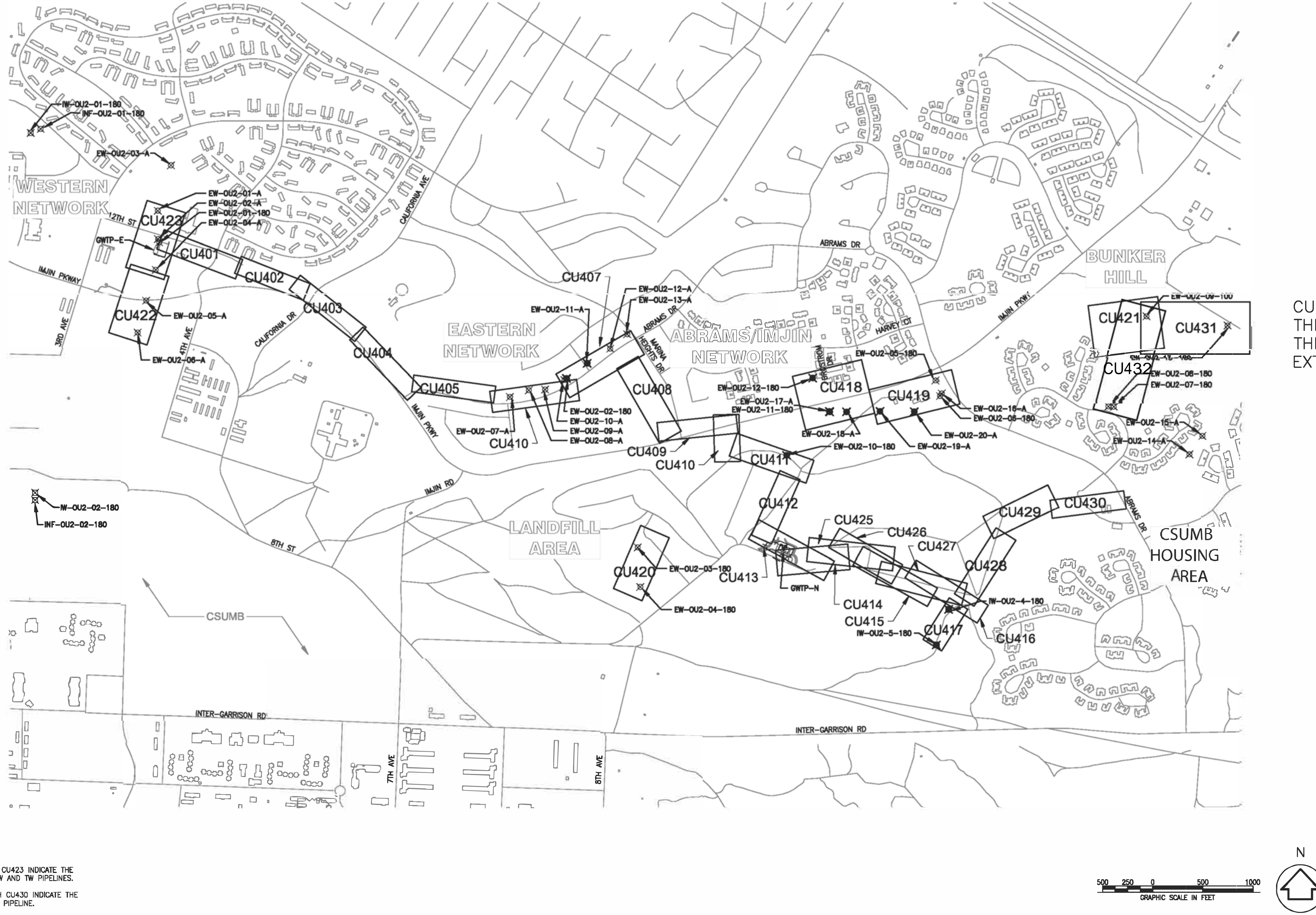
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD

FORT ORD GWTP
INSTRUMENTATION SYMBOLS & ABBREVIATION

SCALE NONE
DRAWING NUMBER CU2
SHEET NUMBER 2 OF 13



CU431 WILL BE THE LOCATION OF THE NEW EXTRACTION WELL

NOTES

1. SHEETS CU401 THOUGH CU423 INDICATE THE ALIGNMENTS FOR THE EW AND TW PIPELINES.
2. SHEETS CU425 THROUGH CU430 INDICATE THE ALIGNMENT FOR THE PW PIPELINE.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
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DRAWN: HR
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SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

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	3				
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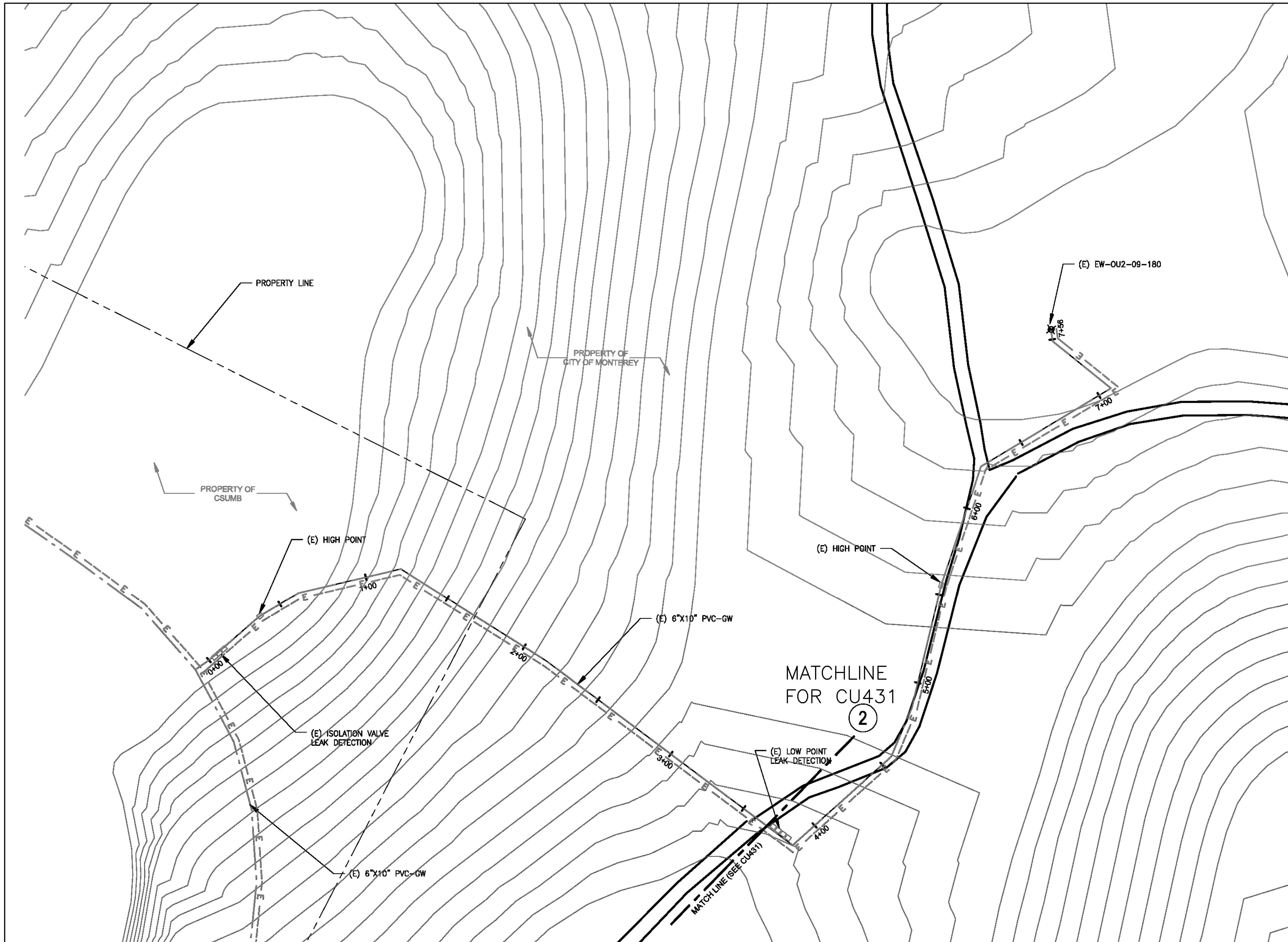
APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
FORT ORD GWTP
FIELD PIPING

SCALE
NOT TO SCALE
DRAWING NUMBER
CU3
SHEET NUMBER
3 OF 13

NOTES

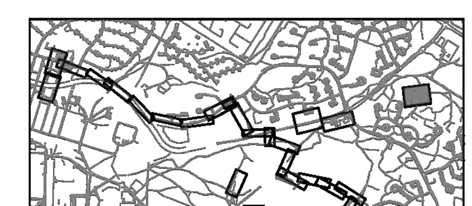
1. EXISTING VAULTS, HIGH POINTS, AND LEAK DETECTION VAULTS ARE BASED ON SURVEY PERFORMED BY POLARIS CONSULTING ON 7/31/2015.
2. SEE SHEET CU501, CU502 AND CU503 FOR WELL SCHEDULE AND ADDITIONAL NOTES ON REDEVELOPMENT AND VIDEO LOGGING OF EXISTING EXTRACTION WELLS, CONSTRUCTION OF NEW EXTRACTION AND INJECTION WELLS, CONVERSION OF EXTRACTION WELL TO MONITORING WELL, AND ABANDONMENT OF EXISTING WELLS.
3. SEE ELECTRICAL AND INSTRUMENTATION DRAWINGS FOR ADDITIONAL INFORMATION ON POWER, LEAK DETECTION, AND INSTRUMENTATION AND CONTROL.
4. WATER PIPE SEPARATION SHOWN ON PLAN VIEW ARE WITH GREATER SEPARATION GRAPHICALLY FOR CLARITY. SEE DETAILS ON CU505 AND CU506 FOR TYPICAL TRENCH SECTIONS.



PLAN VIEW
(EXTRACTION LATERAL LINE FROM EW-OU2-09-180)
SCALE: 1"=30'

N

30 0 30 60
GRAPHIC SCALE IN FEET



KEY PLAN

REVISED AS-BUILT
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DATE: 01/25/2023
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DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

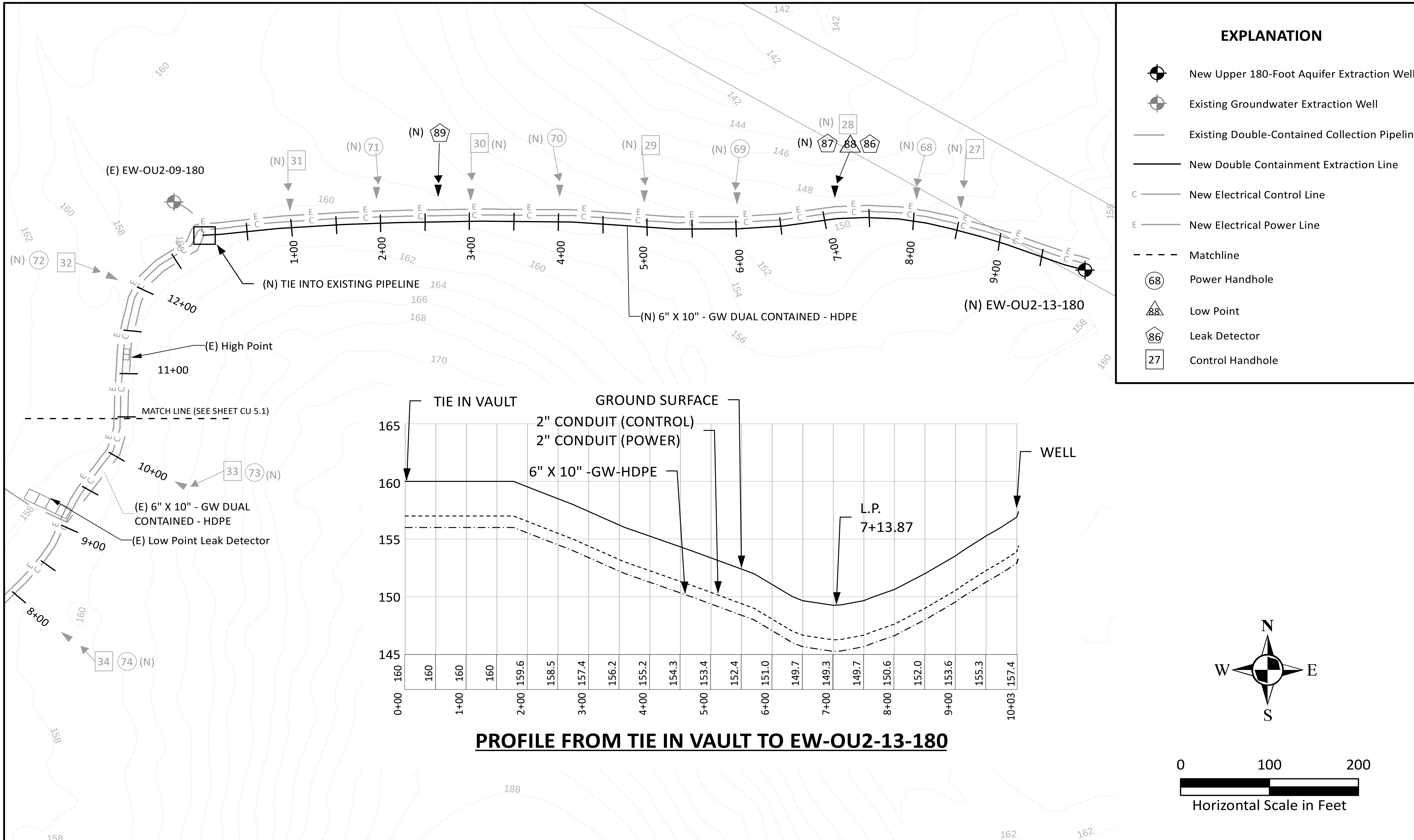
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
FIELD PIPING

SCALE: NONE
DRAWING NUMBER: CU4
SHEET NUMBER: 4 OF 13



PROFILE FROM TIE IN VAULT TO EW-OU2-13-180

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

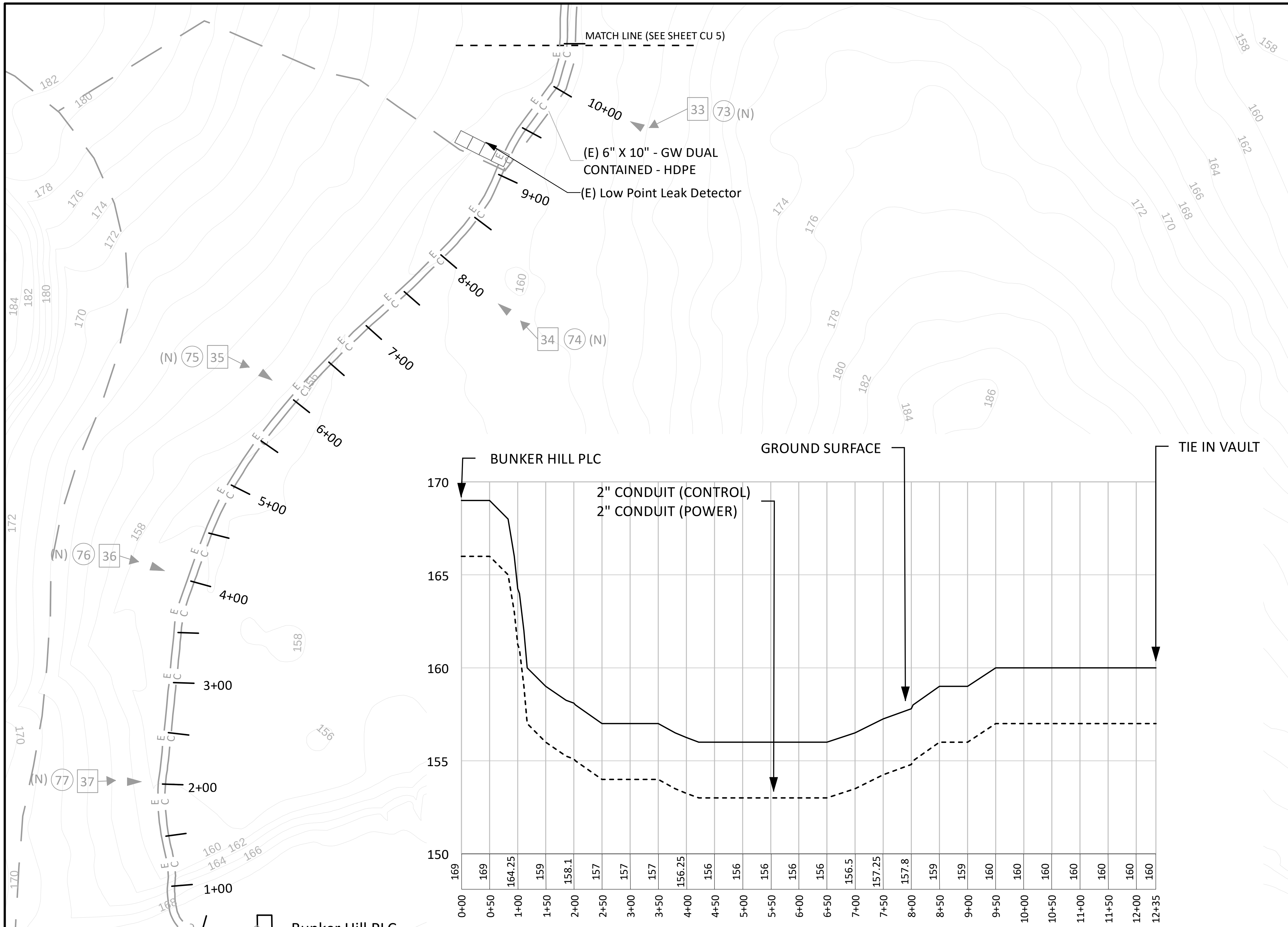
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW–OU2–13–180
FIELD PIPING

SCALE
NONE

DRAWING NUMBER
CU5

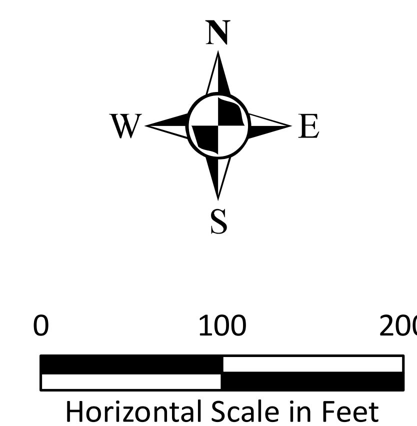
SHEET NUMBER
5 OF 13



PROFILE FROM BUNKER HILL PLC TO TIE IN VAULT

EXPLANATION

- New Upper 180-Foot Aquifer Extraction Well
- Existing Groundwater Extraction Well
- Existing Double-Contained Collection Pipeline
- New Double Containment Extraction Line
- C — New Electrical Control Line
- E — New Electrical Power Line
- Matchline
- 68 Power Handhole
- 88 Low Point
- 86 Leak Detector
- 27 Control Handhole



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SUBMITTED: DATE: SUBMITTAL APPROVED: DATE:	

Ahtna

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE

APPROVED ______ DATE

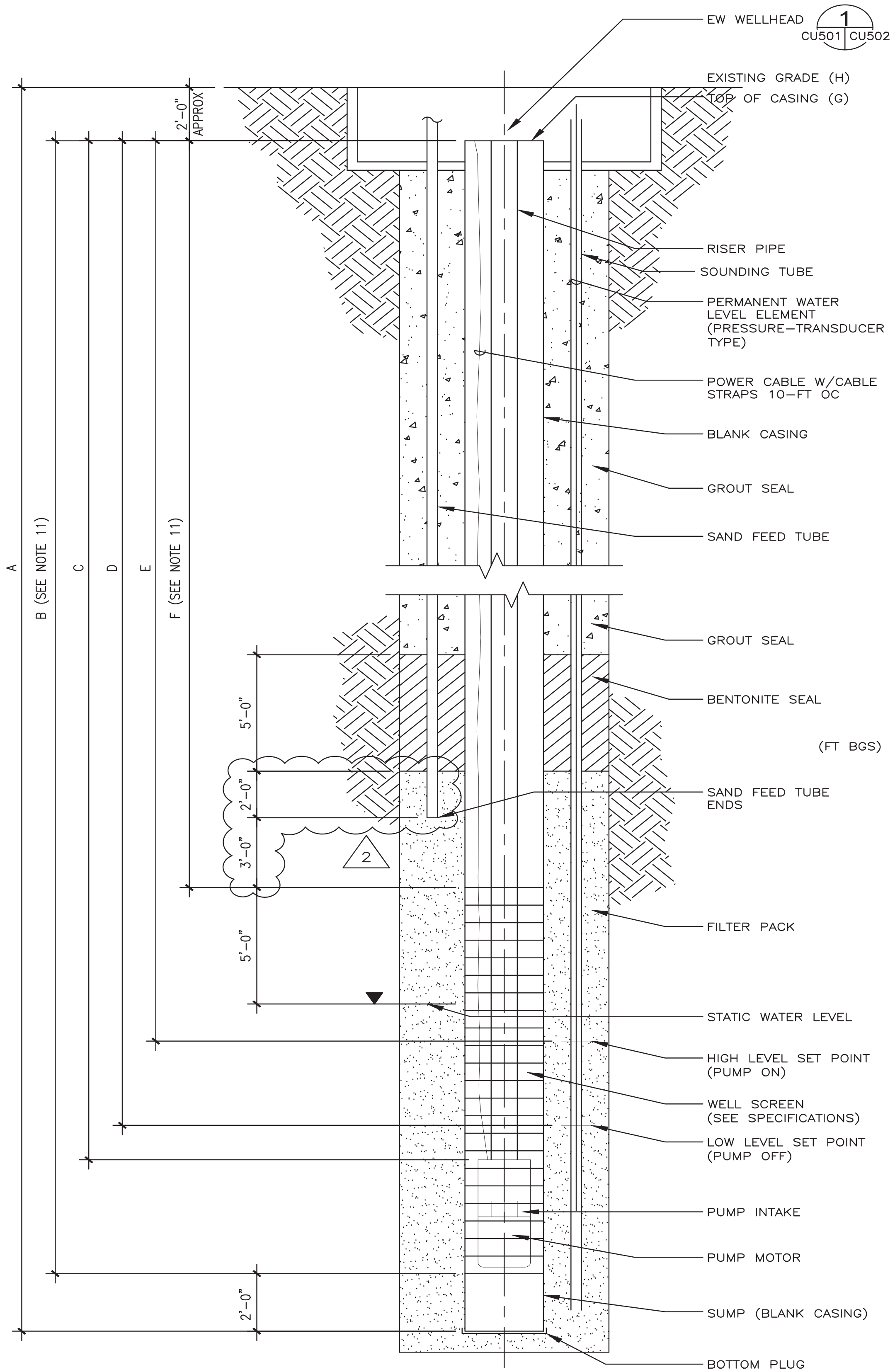
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
FIELD PIPING

SCALE NONE

DRAWING NUMBER CU5.1

SHEET NUMBER 5 OF 13



EW SCHEMATIC

NTS

SCHEDULE OF EXISTING EXTRACTION WELLS

	WELL ID	TOTAL CASING DEPTH (FT BGS) (A)	BOTTOM OF SCREEN (FT BGS) (B)	DEPTH TO TOP OF PUMP (FT BGS) (C)	PUMP-OFF SET PT (FT BTOC) (D)	PUMP-ON SET PT (FT BTOC) (E)	TOP OF SCREEN (FT BGS) (F)	TOC ELEV (FT BTOC) (G)	TOS ELEV (FT BTOC) (H)	NEW PUMP MODEL (I)	FLOW RATE (GPM) (J)	PRESSURE AT TOP OF RISER (PSI) (K)	PRESSURE AT TOP OF RISER + SURGE PRESSURE (L)	(E) PUMP HORSE POWER (HP) (M)	(N) PUMP HORSE POWER (HP) (N)	COMMENT
WESTERN NETWORK																
1	EW-OU2-01-A	144	143				113	109.98	-3.02	-	0			5	-	WELL TO BE OFFLINE
2	EW-OU2-02-A	141.5	139.5				109.5	116.26	6.76	-	0			5	-	WELL TO BE OFFLINE
3	EW-OU2-03-A	116	115				75	84.33	9.33	-	0			5	-	WELL TO BE OFFLINE
4	EW-OU2-04-A	136	135				96	109.473	13.47	-	0			5	-	WELL TO BE OFFLINE
5	EW-OU2-05-A	131	130				100	108.99	8.99	90FA10S4-PE	50	125	160	10	10	REPLACE EXISTING PUMP
6	EW-OU2-06-A	131	130				100	105.57	5.57	90FA10S4-PE	50	125	150	10	10	REPLACE EXISTING PUMP
7	EW-OU2-01-180	174	173				143	110.79	-32.21	2366169020	160	120	165	30	30	REPLACE EXISTING PUMP
EASTERN NETWORK																
8	EW-OU2-07-A	129	128				103	158.56	55.56	-	0			3	-	WELL TO BE OFFLINE
9	EW-OU2-08-A	137	136				106	162.96	56.96	-	0			3	-	WELL TO BE OFFLINE
10	EW-OU2-09-A	137	136				106	162.91	56.91	35FA5S4-PE	31	90	165	3	5	VIDEO, RE-DEVELOP, AND RE-VIDEO, REPLACE EXIST PUMP
11	EW-OU2-10-A	142	141				111	167.58	56.58	35FA5S4-PE	30	90	165	3	5	VIDEO, RE-DEVELOP, AND RE-VIDEO, REPLACE EXIST PUMP
12	EW-OU2-11-A	141	140				110	170.78	60.78	-	-			3	-	ABANDON
13	EW-OU2-12-A	142	141				106	175.39	68.39	60FA5S4-PE	30	80	120	5	5	VIDEO, RE-DEVELOP, AND RE-VIDEO, REPLACE EXIST PUMP
14	EW-OU2-13-A	147	146				116	180.15	64.15	25FA5S4-PE	25	80	100	5	3	VIDEO, RE-DEVELOP, AND RE-VIDEO, REPLACE EXIST PUMP
15	EW-OU2-02-180	241	240				200	167.28	-32.72	-	-			15	-	ABANDON
ABRAMS/IMJIN NETWORK																
16	EW-OU2-16-A	114.5	109.5				79.5	165.43	87.93	35FA5S4	27	90	115	3	5	VIDEO, RE-DEVELOP, AND RE-VIDEO, REPLACE EXIST PUMP
17	EW-OU2-05-180	245	240				180	170.72	-6.78	175STS30D6X-1064	160	90	110	20	30	REPLACE EXISTING PUMP
18	EW-OU2-06-180	235.5	230.5				170.5	166.96	-3.54	150STS25DA-0964	135	90	140	20	25	REPLACE EXISTING PUMP
BUNKER HILL AREA																
19	EW-OU2-07-180	265	260				210	163.39	-46.61	-	0			-	-	WELL TO BE OFFLINE
20	EW-OU2-08-180	220	215				215	162.31	-12.69	-	0			15	-	WELL TO BE OFFLINE
21	EW-OU2-09-180	220	215				175	149.55	-35.13	100SR15F66-1163	55	95	110	7.5	15	REPLACE EXISTING PUMP
CSUMB EAST CAMPUS HOUSING AREA																
22	EW-OU2-14-A	137	129.5				89.5	185.85	96.35	-	0			3	-	WELL TO BE OFFLINE
23	EW-OU2-15-A	142.5	132.5				97.5	194.26	96.76	-	-			3	-	CONVERT TO MONITORING WELL
LANDFILL AREA																
24	EW-OU2-03-180	265	157.5				207	188.39	-18.61	150SR25F66-1163	150	65	95	20	25	REPLACE EXISTING PUMP
25	EW-OU2-04-180	302	294.5				244.5	238.55	-5.95	-	0			20	-	WELL TO BE OFFLINE

SCHEDULE OF NEW EXTRACTION WELLS

	WELL ID	TOTAL CASING DEPTH (FT BGS) (A)	BOTTOM OF SCREEN (FT BGS) (B)	DEPTH TO TOP OF PUMP (FT BGS) (C)	PUMP-OFF SET PT (FT BTOC) (D)	PUMP-ON SET PT (FT BTOC) (E)	TOP OF SCREEN (FT BGS) (F)	TOC ELEV (FT BTOC) (G)	TOS ELEV (FT BTOC) (H)	NEW PUMP MODEL (I)	FLOW RATE (GPM) (J)	PRESSURE AT TOP OF RISER (PSI) (K)	PRESSURE AT TOP OF RISER + SURGE PRESSURE (L)	(E) PUMP HORSE POWER (HP) (M)	(N) PUMP HORSE POWER (HP) (N)	COMMENT
ABRAMS/IMJIN NETWORK																
1	EW-OU2-17-A	117.5	115	109.5			75	167.72	92.72	60FA5S4-PE	30	85	170	-	5	NEW WELL
2	EW-OU2-18-A	107	104.5	99			64.5	161.04	96.54	60FA5S4-PE	30	90	150	-	5	NEW WELL
3	EW-OU2-19-A	112.5	110	104.5			70	165.29	95.29	60FA5S4-PE	30	85	145	-	5	NEW WELL
4	EW-OU2-20-A	124	121.5	116			81.5	177.85	96.35	60FA5S4-PE	30	85	135	-	5	NEW WELL
5	EW-OU2-10-180	305	302.3	297.12			242.3	221.96	-20.34	150SR20F66-0963	130	40	95	-	20	NEW WELL
6	EW-OU2-11-180	241.3	238.5	232.9			178.5	167.20	-11.30	150SR25F66-1163	130	85	105	-	25	NEW WELL
7	EW-OU2-12-180	231.8	229	221.15			169	160.62	-8.38	150STS25DA-0964	130	90	100	-	25	NEW WELL
EASTERN NETWORK																
8	EW-OU2-11-AR	142.5	140	131.69			100	171.31	71.31	90FA7S4-PE	30	80	105	-	7.5	NEW WELL
9	EW-OU2-02-180R	267.8	265	256.64			205	167.30	-37.70	175STS30D6X-1064	130	85	155	-	30	NEW WELL
BUNKER HILL																
10	EW-OU2-13-180	220	215				175	149.55	-35.13					-	20	NEW WELL (ESTIMATION) WELL TO BE INSTALLED

1

NOTES

1. DIMENSIONS ARE IN FEET UNLESS OTHERWISE NOTED.
2. CASINGS AND SCREENS FOR WELLS W/ "A" OR "AR" DESIGNATIONS SHALL BE 6-INCH NOMINAL. CASINGS AND SCREENS FOR WELLS W/ "180" OR "180R" DESIGNATIONS SHALL BE 10-INCH NOMINAL.
3. FOR WELLS TO BE VIDEO LOGGED, SUBCONTRACTOR SHALL PULL ALL EXISTING DOWNHOLE APPURTENANCES BEFORE REHABILITATION AND RE-INSTALL ALL DOWNHOLE APPURTENANCES AFTER REHABILITATION. WELL PUMP AND APPURTENANCES SHALL BE RESTORED TO FULLY OPERATIONAL CONDITION.
4. PUMP MODEL NUMBERS ARE GRUNDFOS.
5. EACH SUBMERSIBLE PUMP SHALL BE INSTALLED WITH SHROUD TO DIRECT INTAKE WATER PAST PUMP MOTOR.
6. RISER PIPES FOR WELLS W/ "A" OR "AR" DESIGNATIONS SHALL BE 1 1/2-INCH NOMINAL PIPES. RISER PIPES FOR WELLS W/ "180" OR "180R" DESIGNATIONS SHALL BE 3-INCH NOMINAL PIPES.
7. CONVERSION OF EW-OU2-15-A TO MONITORING WELL (MW) SHALL INCLUDE REMOVAL OF PUMP, PIPING, ELECTRICAL AND PUMPING APPARATUS FROM WELL AND VAULT AND PLACEMENT OF MONITORING WELL HEAD. EXTEND WELL CASING WITH A 3' STICK-UP ABOVE GROUND SURFACE USING SIMILAR MATERIAL AS WELL CASING. PROVIDE AN ALUMINUM PROTECTIVE CASING WITH A LOCKING HINGED LID OVER THE WELL CASING STICK-UP AND GROUT IN PLACE. A 3'X3'X4" CONCRETE PAD SHALL BE INSTALLED AROUND THE WELL HEAD. INSTALL FOUR BOLLARDS PAINTED SAFETY YELLOW AND FILLED WITH CEMENT. THE BOLLARDS SHALL BE MINIMUM 2" DIAMETER, EXTEND 3' BELOW GROUND SURFACE AND STICKING UP 3' ABOVE GROUND SURFACE. THE WELL ID TAG SHALL INCLUDE WELL ID, WELL DEPTH, SCREENED INTERVAL DEPTH, GROUND SURFACE ELEVATION, AND DATE INSTALLED.
8. TBD DURING WELL DRILLING:
   COLUMN (C): DEPTH TO TOP OF PUMP TBD DURING WELL DRILLING
   COLUMN (D): PUMP - OFF SET POINT
   COLUMN (E): PUMP - ON SET POINT
   COLUMN (G): TOP OF CASING (FOR NEW WELLS)
   COLUMN (H): TOP OF SURFACE (FOR NEW WELLS)
9. SCREENED INTERVAL FOR SOUNDING TUBE SHALL MATCH SCREENED INTERVAL FOR WELL.
10. SEE SPECIFICATIONS FOR WELL CONSTRUCTION MATERIALS.
11. ELEVATIONS OF TOP OF SCREEN AND BOTTOM OF SCREEN ARE ESTIMATED. ACTUAL ELEVATIONS SHALL BE SET IN THE FIELD BY THE PROJECT GEOLOGIST. THE TOP OF SCREENED INTERVAL SHALL BE AT LEAST 5 FEET ABOVE THE STATIC WATER LEVEL.
12. COLUMN (H) SURFACE ELEVATIONS AT EACH EW TBD AFTER DRILLING.
13. ALL PUMP MOTORS ARE 480V/3P.

1.IS BEING PROPOSED FOR THE NEW EXTRACTION WELL.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

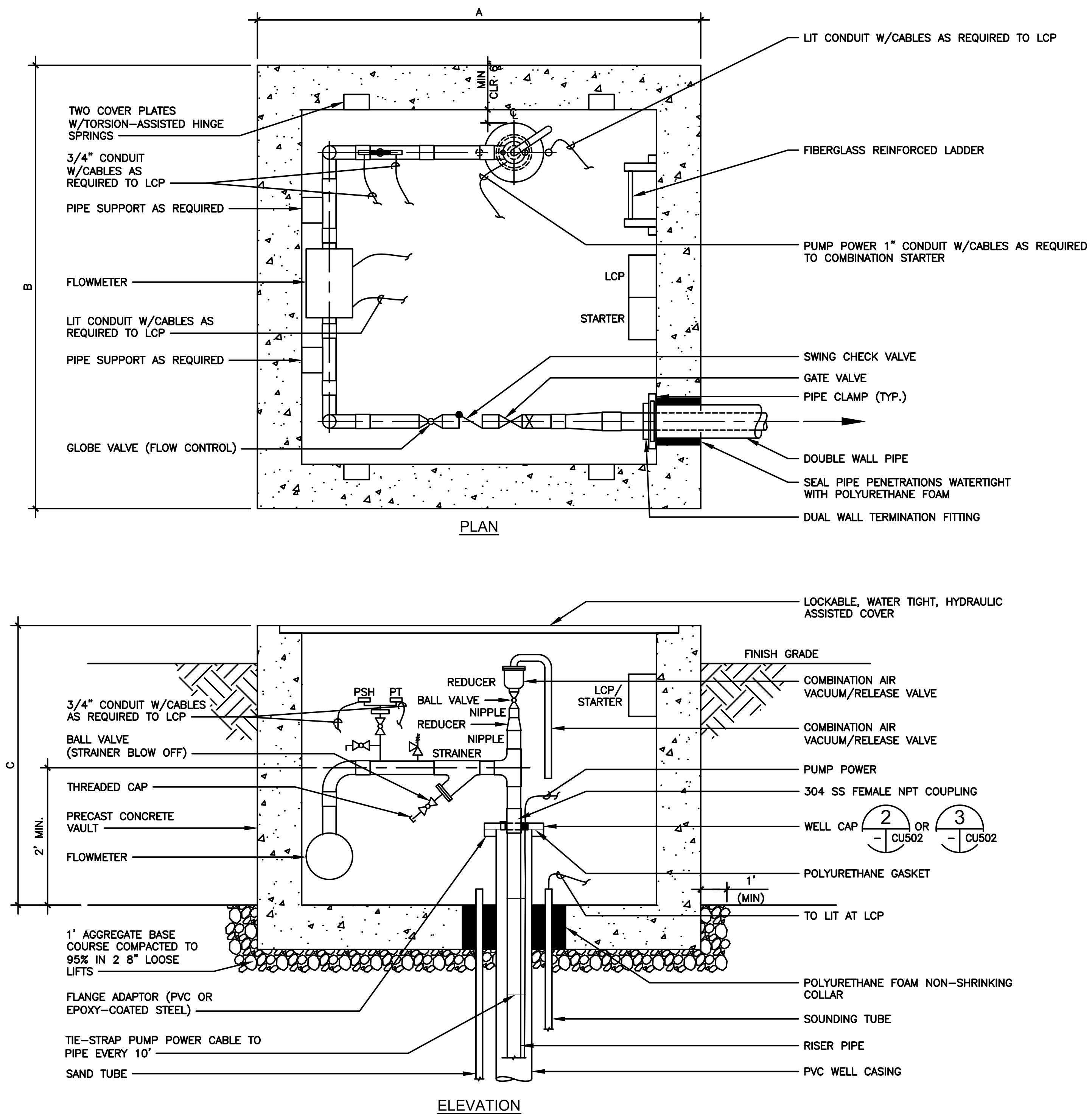
Ahtna

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.
		1 2 3			
	4				

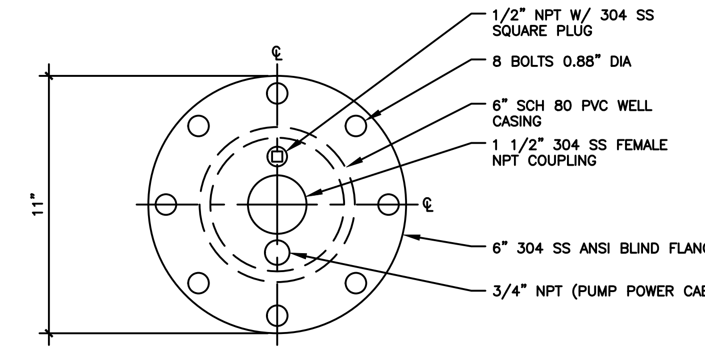
APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
EXTRACTION WELL SCHEMATIC

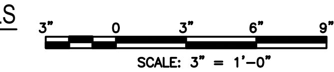
SCALE: NOT TO SCALE
DRAWING NUMBER: CU6
SHEET NUMBER: 6 OF 13

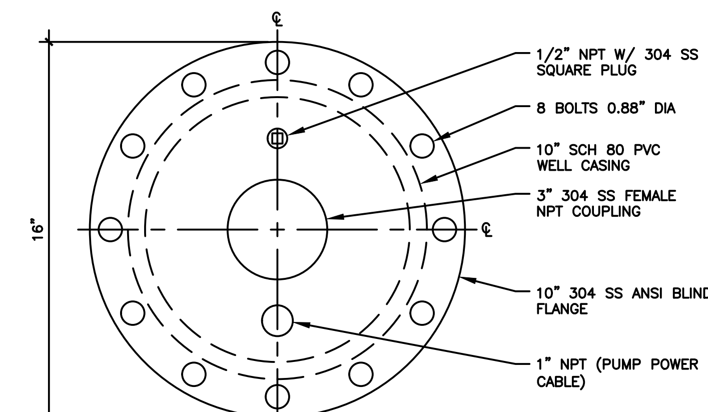


1 EW WELLHEAD
CU501 | CU502 NTS

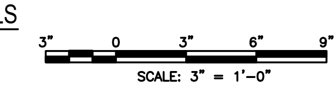


2 WELL CAP - A-AQUIFER WELLS
CU501 | CU502 SCALE: 3"=1'-0"





3 WELL CAP - 180-FT-AQUIFER WELLS
CU501 | CU502 SCALE: 3"=1'-0"



GRADE LOAD REQUIREMENT – WELL VAULTS

A. 150 PSI
B. H-20 OFF-STREET LOCATION (OCCASIONAL H20 LOADING)

CLASS WATER TIGHTNESS REQUIREMENT – WELL VAULTS

1. NONE – PROVIDE 1 1/2"DIA HOLE 6" FROM EACH CORNER OF EACH LEAF
2. WATER RESISTANT
3. WATER TIGHT

NOTES:

1. DRILLER SHALL INSTALL TEMPORARY CS SLEEVE TO PROTECT WELL CASING EXTENDING APPROXIMATELY 3' ABOVE GRADE.
2. CLASS 2 AND 3 VAULT COVERS SHALL BE EQUIPPED WITH A JOINT GUTTER AND A MOAT TYPE EDGE DRAIN. A 1 1/2" DIA MIN DRAIN CONNECTION SHALL BE PROVIDED.
3. ALL HATCHES SHALL INCLUDE A RECESSED HASP FOR A PADLOCK THAT IS COVERED BY A HINGED LID FLUSH WITH THE SURFACE.
4. COVER SHALL BE GASKET-SEALED AND TORSION-SPRING ASSISTED.
5. ALL HARDWARE FOR THE COVER SHALL BE 304 SS.
6. PRECAST CONCRETE REQUIREMENTS:
   CONCRETE SHALL HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 4000 PSI. THE VAULT SHALL BE DESIGNED IN ACCORDANCE WITH ACI 318-89 FOR THE FOLLOWING LATERAL SOIL LOADINGS:
   70 PCF EQUIVALENT FLUID PRESSURE SURCHARGE
   240 PSF FOR WELLHEADS WITH GRADE B OR C COVERS.
7. SEAL ALL PENETRATIONS WITH NON-SHRINKING POLYURETHANE FOAM AND SPECIFICATION.
8. FOR ELECTRICAL REQUIREMENTS SEE ELECTRICAL SHEETS.
9. ALL CABLES EXPOSED TO PHYSICAL DAMAGE SHALL BE RUN IN CONDUIT.
10. SEE SHEET M-501 FOR DETAILS FOR SAMPLE PORTS AND PRESSURE INSTRUMENTS.

NOT FOR CONSTRUCTION

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DATE: 01/25/2023
FILE:
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DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

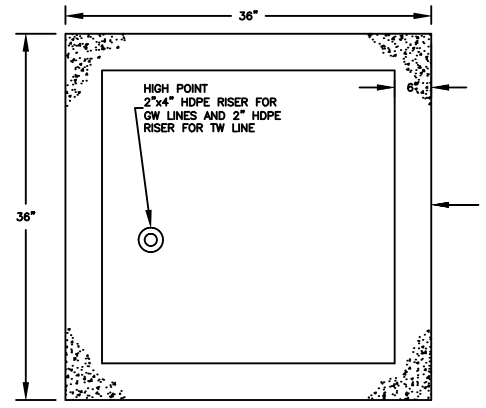
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

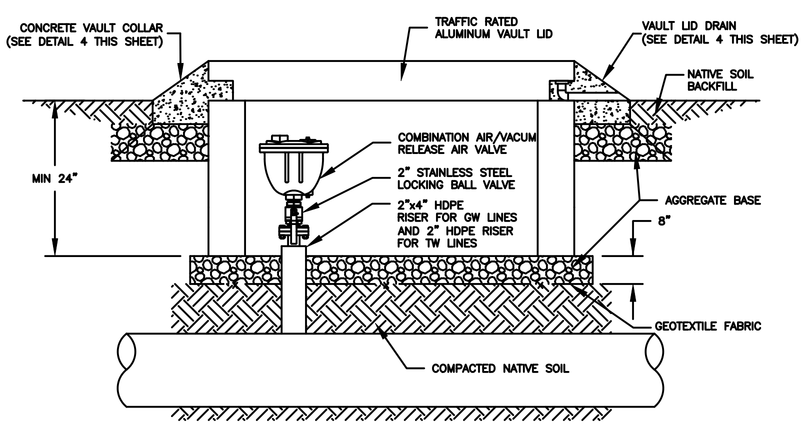
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
EXTRACTION WELLHEAD DETAILS

SCALE: NONE
DRAWING NUMBER: CU7
SHEET NUMBER: 7 OF 13



PLAN VIEW

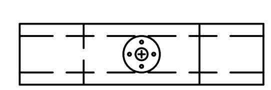


CROSS SECTION

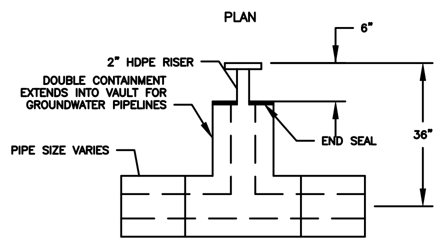
NOTES

1. AT HIGH POINTS INSTALL NON-SHOCK COMBINATION VACUUM BREAK AND PRESSURE RELEASE VALVE ON RISER.

1 HIGH POINT VAULT
CU SHEET | CU507 SCALE: N.T.S.

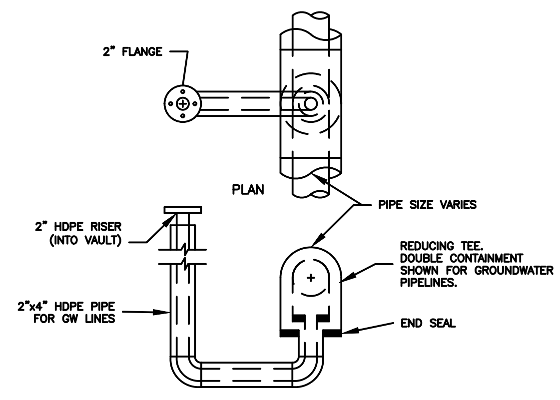


PLAN



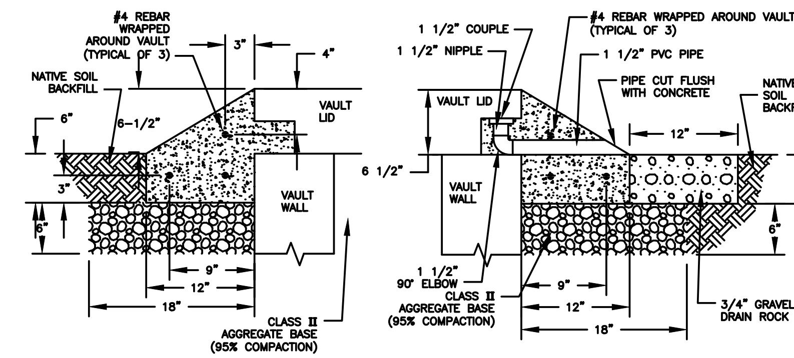
CROSS SECTION

2 HIGH POINT VENT DETAIL
CU SHEETS | CU507 SCALE: N.T.S.

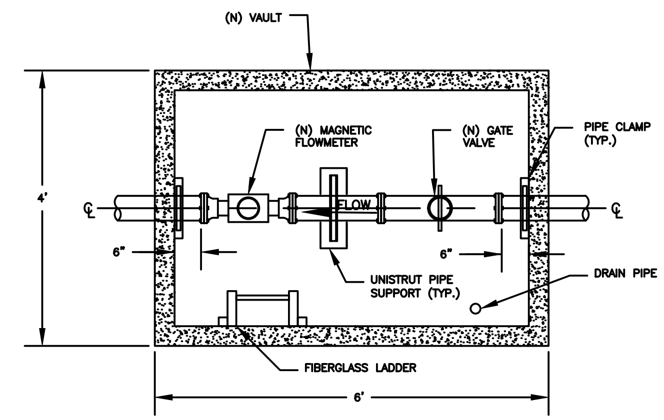


CROSS SECTION

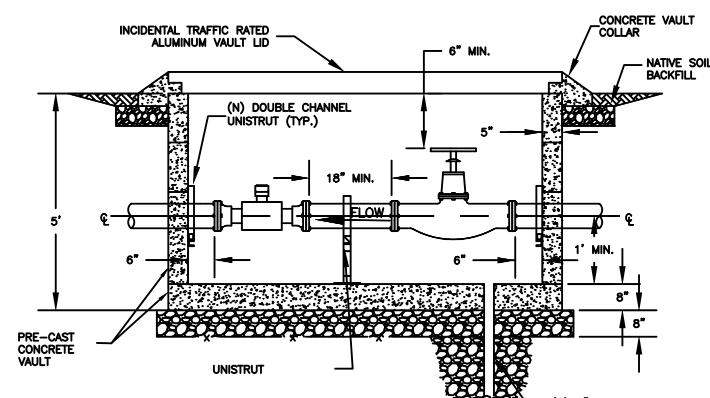
3 LOW POINT DRAIN DETAIL
CU SHEETS | CU507 SCALE: N.T.S.



4 LOW/HIGH POINT VAULT
CU SHEETS | CU507 SCALE: N.T.S.



PLAN VIEW

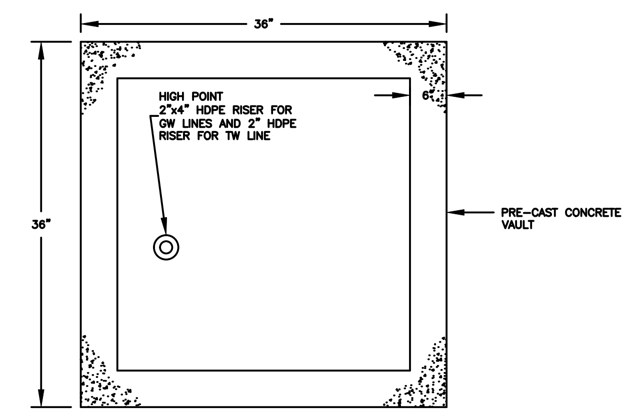


CROSS SECTION

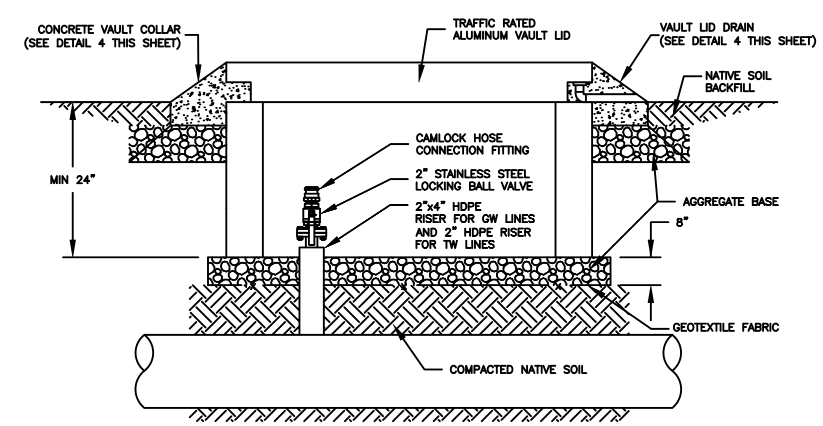
NOTES

1. A MINIMUM OF FIVE (5) PIPE DIAMETERS OF STRAIGHT PIPE MUST BE MAINTAINED FROM THE CENTER OF THE MAGNETIC FLOWMETER ON THE UPSTREAM SIDE.
2. A MINIMUM OF TWO (2) PIPE DIAMETERS OF STRAIGHT PIPE MUST BE MAINTAINED FROM THE CENTER OF THE MAGNETIC FLOWMETER ON THE DOWNSTREAM SIDE.
3. A MINIMUM OF TEN (10) PIPE DIAMETERS OF STRAIGHT PIPE MUST BE MAINTAINED FROM THE CENTER OF THE MAGNETIC FLOWMETER TO ANY PIPE TEE ON THE UPSTREAM SIDE.
4. FOR ADDITIONAL INFORMATION ON THE MAGNETIC FLOWMETER, REFER TO ELECTRICAL, INSTRUMENTATION, AND CONTROLS DRAWINGS.

5 FLOW METER VAULT
CU423 | CU507 SCALE: N.T.S.



PLAN VIEW



CROSS SECTION

NOTES

1. AT HIGH POINTS INSTALL NON-SHOCK COMBINATION VACUUM BREAK AND PRESSURE RELEASE VALVE ON RISER.

6 LOW POINT VAULT
CU SHEET | CU507 SCALE: N.T.S.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

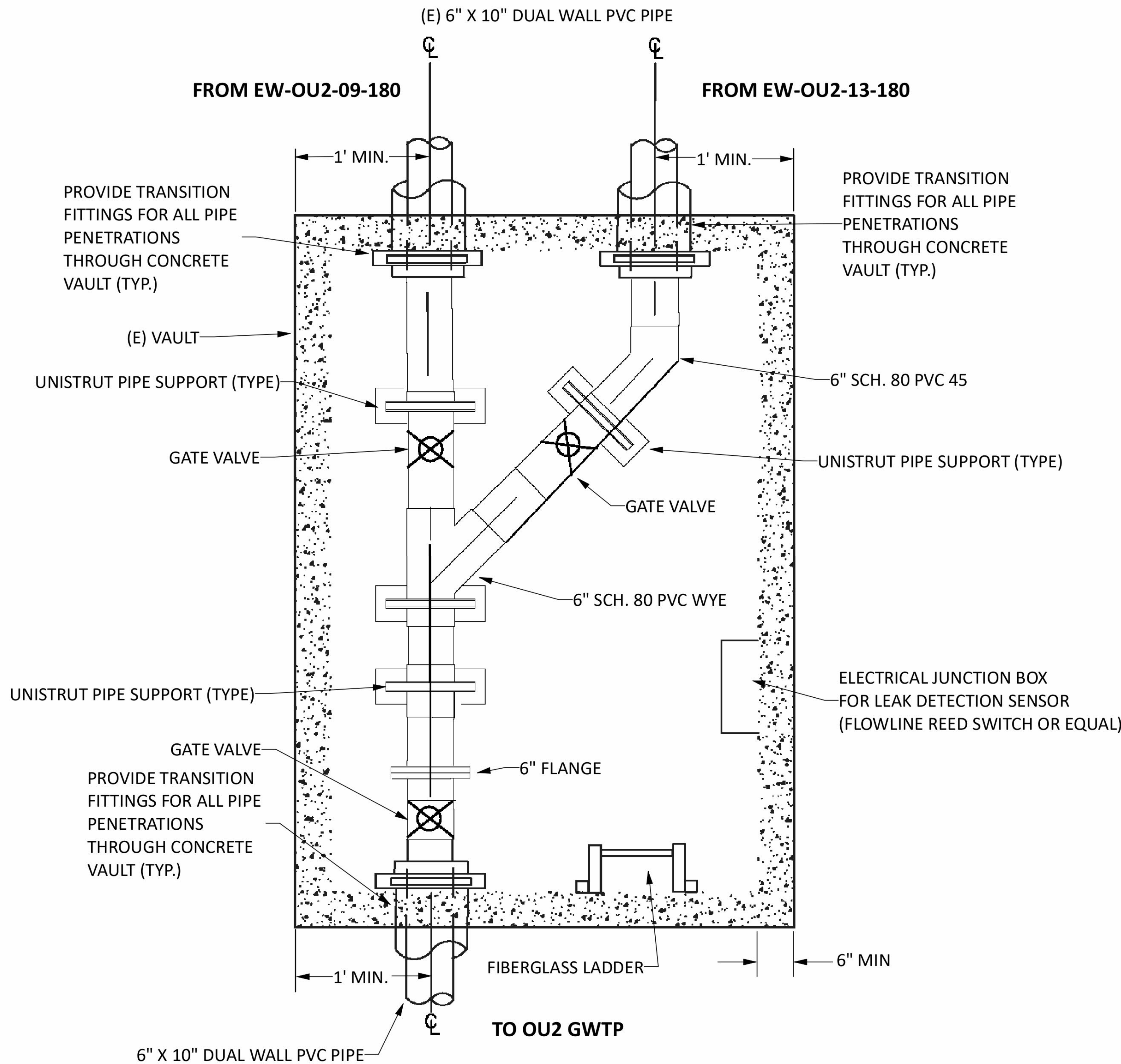
APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
VAULT DETAILS

SCALE
NOT TO SCALE
DRAWING NUMBER
CU8
SHEET NUMBER
8 OF 13



NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

REVISIONS

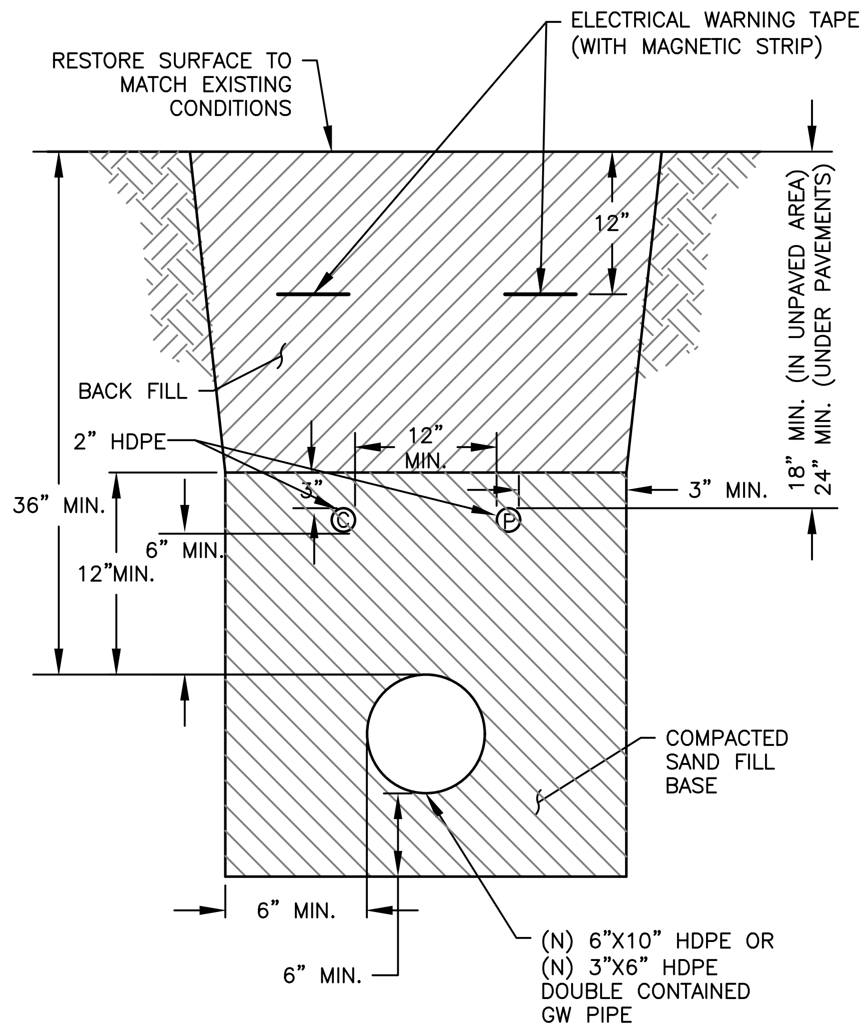
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
VAULT PIPING DETAILS

SCALE NONE
DRAWING NUMBER CU9
SHEET NUMBER 9 OF 13

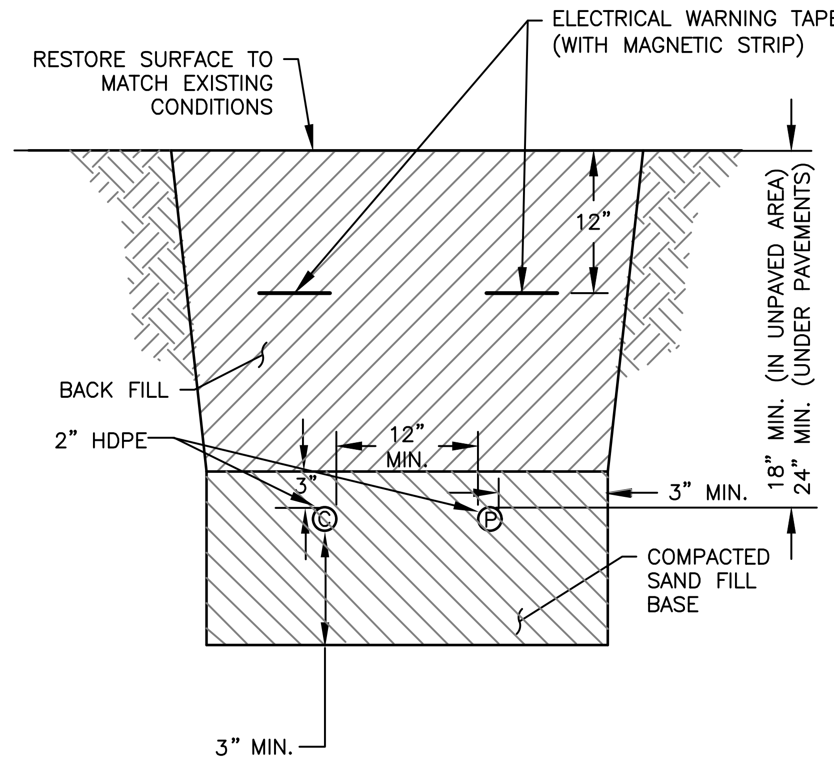


NOTE:
1. FROM EW-OU2-13-180 TO TIE-IN VAULT

1 TRENCH DETAIL

CU5 | CU10
CU13
S15

SCALE : N.T.S.



NOTE:
1. FROM TIE-IN VAULT TO BUNKER HILL PLC

2 TRENCH DETAIL

CU5.1 | CU10
CU12
CU13.1
S14
S15.1

SCALE : N.T.S.

CONDUIT LEGEND
Ⓒ – CONTROL CONDUIT (2" PVC)
Ⓟ – POWER CONDUIT (2" PVC)

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"–SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

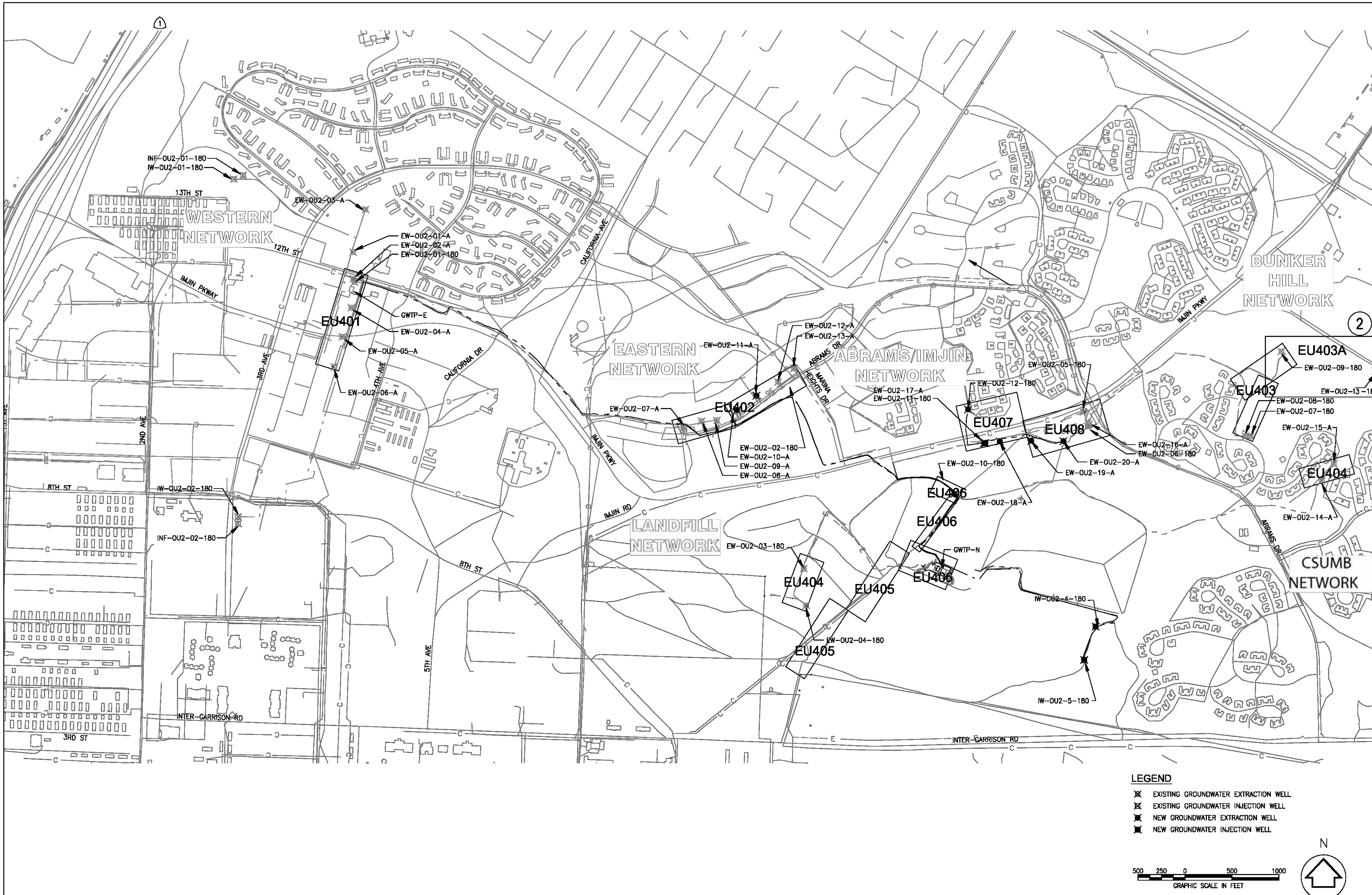
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	3				
	4				

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL NETWORK
TRENCH DETAILS

SCALE
NOT TO SCALE
DRAWING NUMBER
CU10
SHEET NUMBER
10 OF 13



2 ADDED KEYBOX EU403A FOR NEW EXTRACTION WELL.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

Ahtna

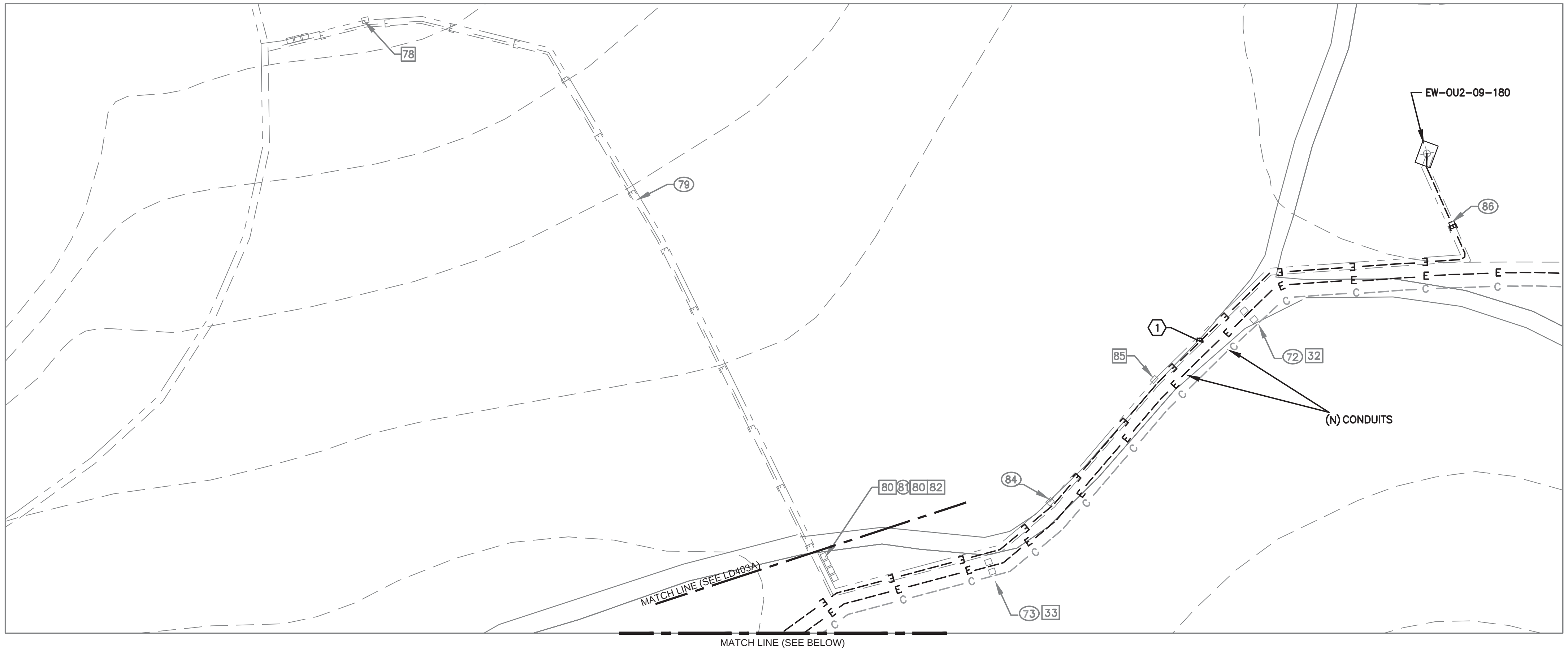
REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	3				
	4				

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

FORT ORD GWTP
FIELD ELECTRICAL MAP

SCALE: NOT TO SCALE
DRAWING NUMBER: CU11
SHEET NUMBER: 11 OF 13



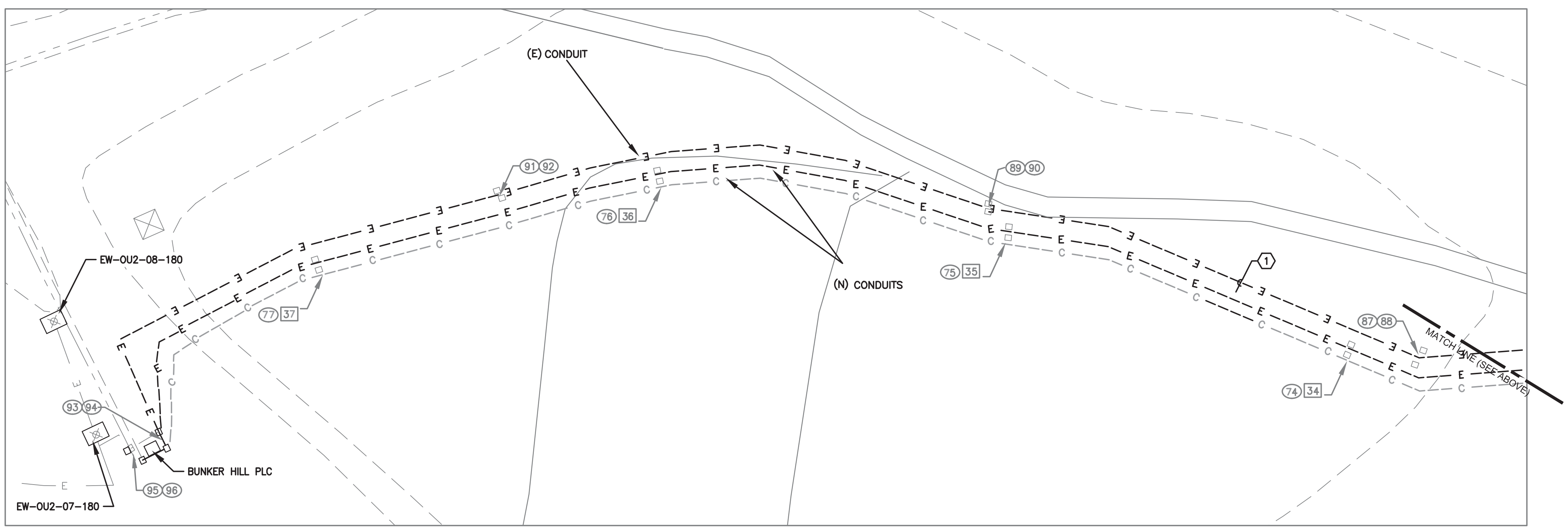
1 BUNKER HILL NETWORK
SCALE 1 : 30

GENERAL NOTES

1. FOR ALL (N) UNDERGROUND METALLIC STRUCTURES PROVIDE CORROSION PROTECTION. THE CONTRACTOR MAY MODIFY THE CATHODIC PROTECTION SYSTEM AS SHOWN IN DETAILS ON E-504 AFTER SITE VERIFICATION AND ANALYSIS.
2. FOR TRAFFIC AND NON-TRAFFIC HANDHOLES SEE DETAIL 1 ON IU501 AND DETAIL 13 ON E-502.
3. SEE CU SHEETS FOR ADDITIONAL TRENCH PROFILES AND DETAILS.

KEYED NOTES

~~1 (N) CONDUCTORS IN (E) CONDUITS.~~



2 BUNKER HILL NETWORK
SCALE 1 : 30

KEY PLAN

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)	DATE: 01/25/2023 FILE: DRAWN: HR DESIGNED: AHTNA CHECKED:
SUBMITTED:	DATE:
SUBMITTAL APPROVED:	DATE:

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE

APPROVED ______ DATE

CONTRACT NUMBER

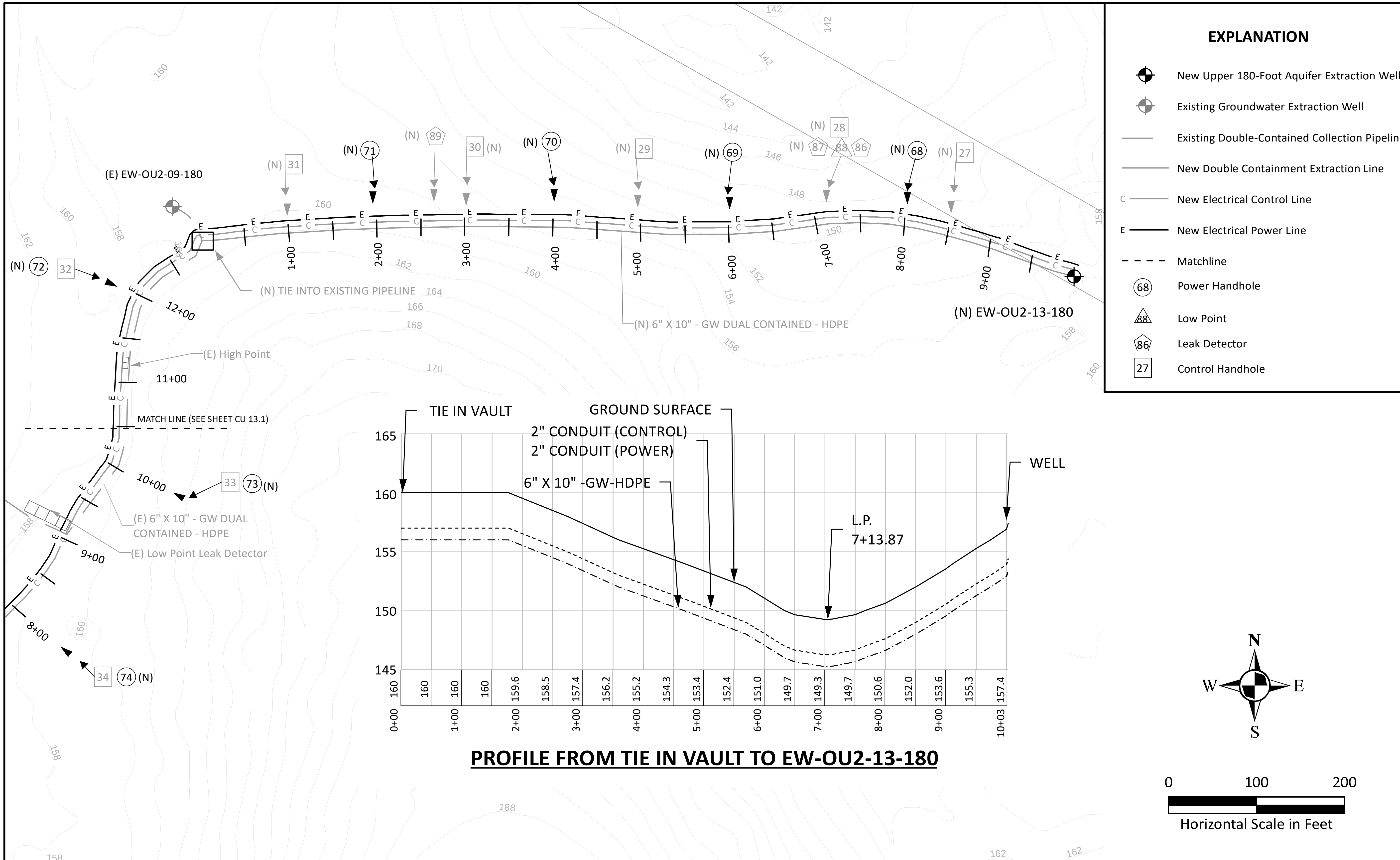
AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL
FIELD ELECTRICAL MAP

SCALE
NONE

DRAWING NUMBER
CU12

SHEET NUMBER
12 OF 13



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SUBMITTAL APPROVED:	DATE:

Ahtna

REVISIONS

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APPROVAL RECOMMENDED ____ DATE

APPROVED ____ DATE

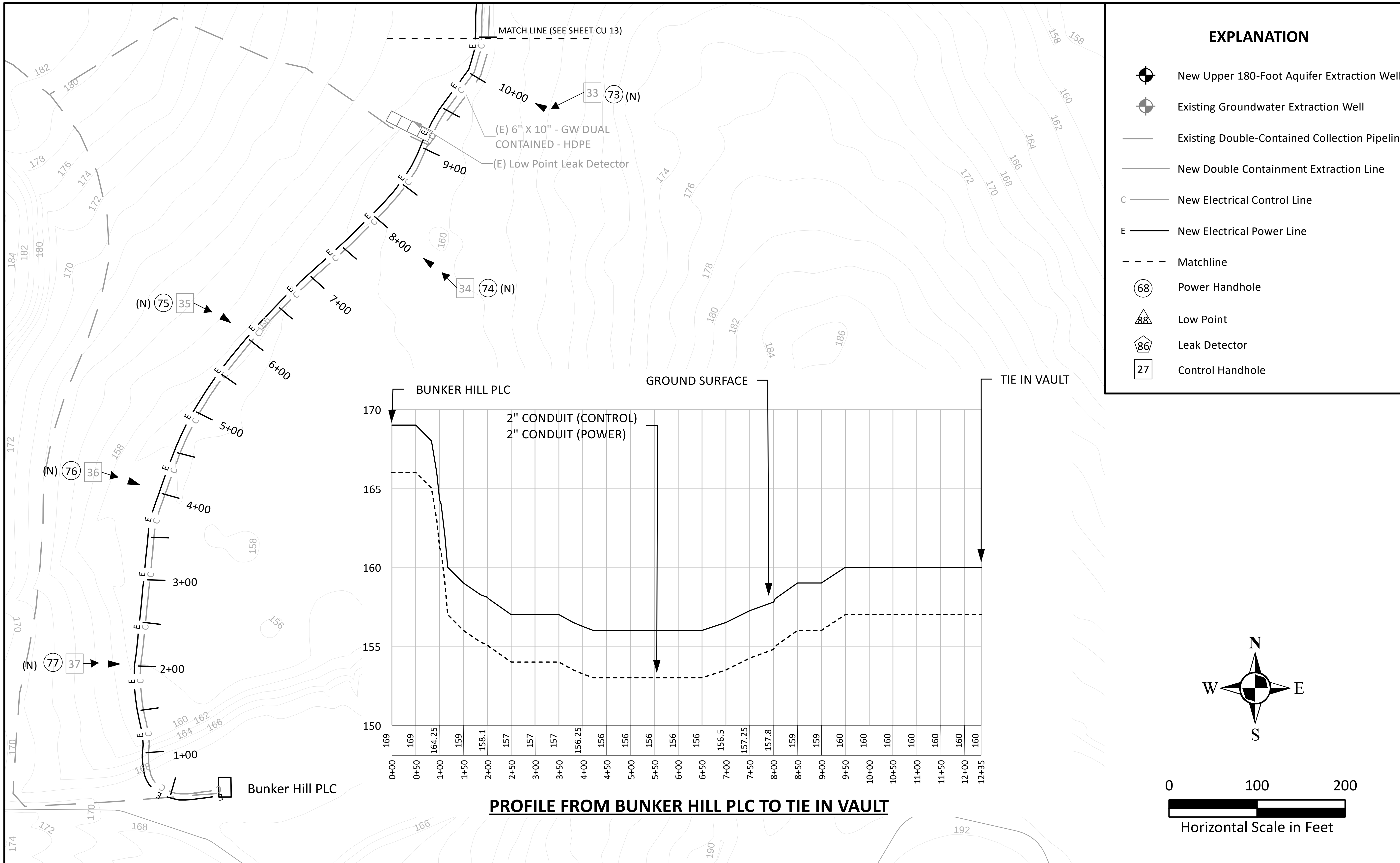
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW–OU2–13–180
FIELD ELECTRICAL MAP

SCALE NONE

DRAWING NUMBER CU13

SHEET NUMBER 13 OF 13



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CHECKED:

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SUBMITTAL APPROVED: ______ DATE: ______

Ahtna

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
FIELD ELECTRICAL MAP

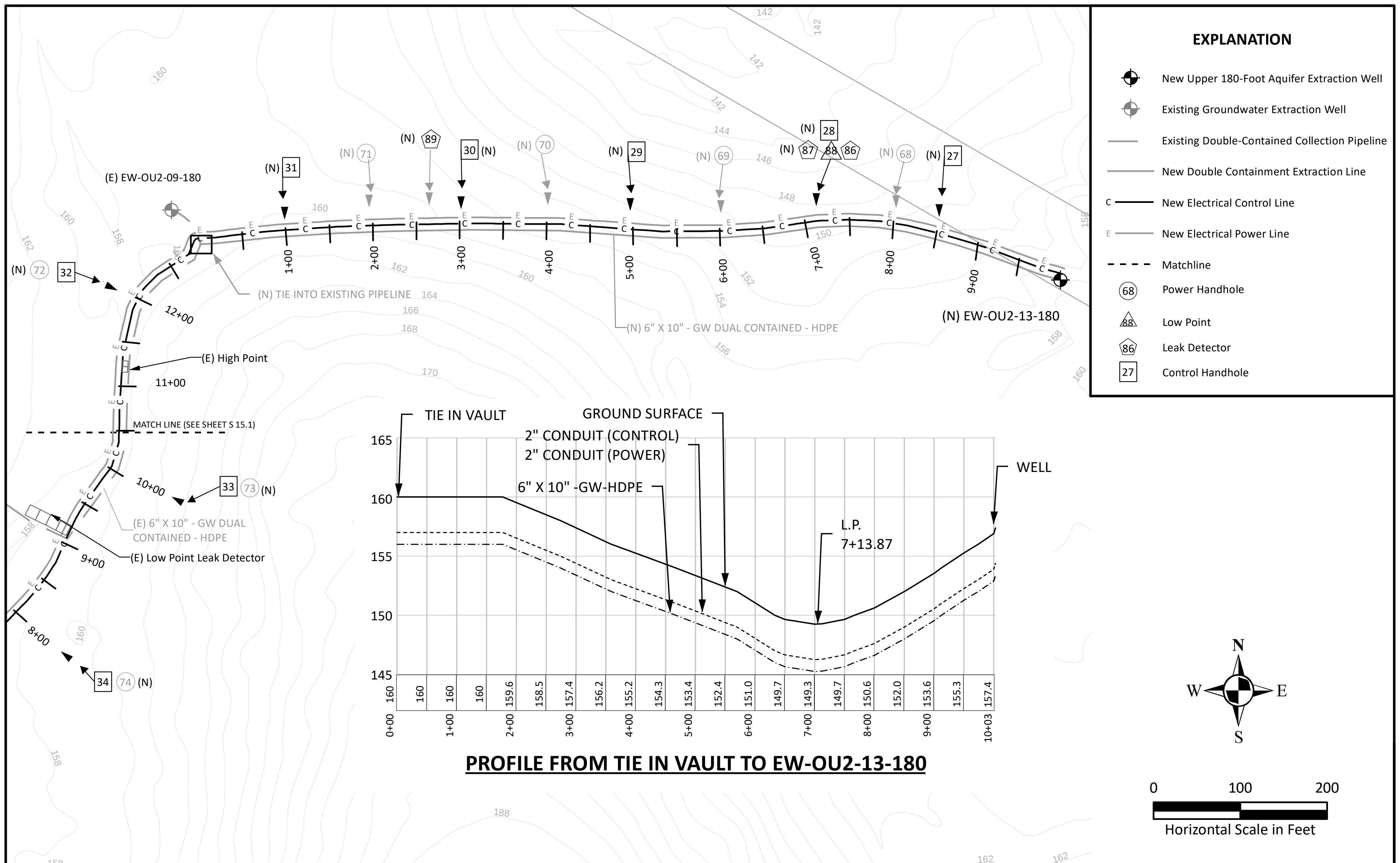
SCALE
NONE

DRAWING NUMBER
CU13.1

SHEET NUMBER
13 OF 13

UPPER 180-FOOT AQUIFER REMEDIAL DESIGN
ELECTRICAL DESIGN PLAN

FORMER FORT ORD, CALIFORNIA



INSTRUMENTATION DRAWING INDEX

FORT ORD, CA

SHEET NO.	DRAWING NO.	DRAWING TITLE
1	S1	COVER SHEET
2	S2	INSTRUMENTATION SYMBOLS AND ABBREVIATIONS
3	S3	ELEMENTARY DIAGRAM
4	S4	P&ID EW-OU2-08-180
5	S5	P&ID EW-OU2-09-180
6	S6	P&ID EW-OU2-13-180
7	S7	LADDER DIAGRAM DIGITAL
8	S8	LADDER DIAGRAM ANALOG
9	S9	ONE LINE
10	S10	INTERNAL PANEL LAYOUT
11	ELD01	FLOW TRANSMITTER LOOP DIAGRAM
12	ELD02	LEVEL TRANSMITTER LOOP DIAGRAM
13	ELD03	PRESSURE TRANSMITTER LOOP DIAGRAM
14	S14	CONDUIT NETWORK ROUTING
15	S15	CONDUIT EXTRACTION WELL ROUTING
16	S15.1	CONDUIT EXTRACTION WELL ROUTING
17	S16	COMMUNICATION HUB
18	S17	LEAK DETECTION DETAILS
19	S18	LEAK DETECTION SCHEMATIC

NOT FOR CONSTRUCTION

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KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
COVER SHEET

SCALE NONE
DRAWING NUMBER S1
SHEET NUMBER 1 OF 18

PUMP AND BLOWER SYMBOLS

- CENTRIFUGAL PUMP, INCLUDES MOTOR
- SUMP PUMP
- SUBMERSIBLE WELL PUMP
- BLOWER
- METERING PUMP
- WELL VAULT

VALVE SYMBOLS

- BALL VALVE
- BUTTERFLY VALVE, CLOSED
- BUTTERFLY VALVE, OPEN
- CHECK VALVE
- DIAPHRAGM VALVE
- GATE VALVE
- SAMPLE PORT (NORMALLY CLOSED)
- GLOBE VALVE
- AIR VENT/VACUUM VALVE
- THREE WAY VALVE

MISCELLANEOUS SYMBOLS

- PROPOSED EXTRACTION WELL
- EXISTING EXTRACTION WELL
- PROPOSED TRANSFORMER
- EXISTING TRANSFORMER
- TREATMENT PLANT
- PULL BOX
- EXTRACTION WELL CONCRETE PAD
- CONDUIT RUN UNDER PAVED AREA

LINE SYMBOLS

- PRIMARY PROCESS FLOW LINE
- UTILITY/SECONDARY PROCESS LINE
- SOFTWARE/COMMUNICATION LINK
- ELECTRIC SIGNAL OR POWER
- INSTRUMENT AIR SUPPLY LINE
- LIMIT LINE
- FENCE
- EXT — **EXISTING EXTRACTION PIPELINE**
- W — **EXISTING WATER LINE**
- E — **EXISTING ELECTRICAL LINE**

DETAIL/SECTION REFERENCE

FT
2020

FIRST LETTER
SUCCEEDING LETTER

FIRST TWO NUMBERS: WELL NUMBER
SECOND TWO NUMBERS: INSTRUMENT NUMBER

WELL NOMENCLATURE

EWC5

WELL IDENTIFIER

EXTRACTION WELL

ELECTRICAL SYMBOLS

- NORMALLY OPEN RELAY CONTACT
- NORMALLY CLOSED RELAY CONTACT
- GROUND
- CIRCUIT BREAKER
- PRESSURE SWITCH
- FLOAT SWITCH
- ON/OFF SWITCH
- FUSABLE PULLOUT
- NORMALLY OPEN MOMENTARY PUSH BUTTON
- NORMALLY CLOSED MOMENTARY PUSH BUTTON
- OL CONTACTOR
- TRANSFORMER
- THERMAL OVERLOAD DEVICE
- 3#10 — THREE NUMBER 10 CONDUCTORS
- 5 — MOTOR WITH 5 HP
- CURRENT SENSING RELAY
- EMP — ELECTRONIC METERING AND PROTECTION PANEL
- OFF / ON — TWO POSITION CONTACT SWITCH

INPUT/OUTPUT SCHEMATIC LAYOUT

- FIELD INSTRUMENT
- 3 WAY SELECTOR SWITCH
- NORMALLY CLOSED CONTACT
- TERMINAL BLOCK
- FUSE
- FIELD WIRING
- PANEL/VAULT WIRING
- COIL
- PROGRAMMABLE SOLID STATE RELAY

PANEL LAYOUT (S10)

COMPONENT	DESCRIPTION
A	5 PORT MANAGED ETHERNET SWITCH
B	PHOENIX DIN BUSSMANN RAIL FUSED TERM BLOCK 110V
C	TRIPLE LEVEL SCREW TYPE TERMINAL BLOCKS
D	DIN RAIL FUSE TERMINAL BLOCKS
E	24 VDC POWER SUPPLY
F	SINGLE PORT 5-15 OUTLET
G	10A CIRCUIT BREAKER
H	15A CIRCUIT BREAKER
I	3 POLE DIN RAIL MOUNT SWITCH DISCONNECTOR
J	PLC
K	ANALOG INPUT EXPANSION CARD
L	ANALOG OUTPUT EXPANSION CARD
M	24 VDC ISOLATION RELAY
N	FUSED TERMINAL BLOCKS
O	15A CIRCUIT BREAKER
P	VFD
Q	POWER DISTRIBUTION BLOCK
R	480VAC -120VAC TRANSFORMER
S	LEVEL SWITCH

INSTRUMENT ABBREVIATIONS

Instrument Abbreviations

	Alarm L-low H-high	Controller	Control Valve	Detection Element	Glass Guage	Indicator	Integrator	Relay/ Compute	Safety Valve	Switch L-low H-high	Transmitter	Well or Probe	Interlock L-low H-high
Analysis	AAL AAH	AC	AV	AE		AI		AY		ASL ASH	AT	AW	
Flow	FAL FAH	FC	FV	FE	FG	FI	FO	FY		FSL FSH	FT		FAXL FAXH
Hand		HC	HV					HY					
Level	LAL LAH	LC	LV	LE	LG	LI		LY		LSL LSH	LT	LW	LAXL LAXH
Pressure or Vacuum	PAL PAH	PC	PV	PE		PI		PY		PSL PSH	PT		PAXL PAXH
Pressure Differential	PDAL PDAH	PDC	PDV	PDE		PDI		PDY	PSV	PDSL PDSH	PDT		
Speed or Frequency	SAL SAH	SC	SV	SE		SI	SO	SY		SSL SSH	ST		SAXL SAXH
Temperature	TAL TAH	TC	TV	TE		TI		TY	TSV	TSL TSH	TT	TW	TAXL TAXH
Vibration	VAL VAH			VE		VI		VY		VSL VSH	VT		VAXL VAXH
Position	ZAL ZAH	ZC		ZE		ZI		ZY		ZSL ZSH	ZT		
Electrical Current	ISL ISH			IE		II		IY		ISL ISH	IT		IAXL IAXH

INSTRUMENT INDENTIFIERS

Instrument Identification Letters

	FIRST LETTER		SUCCEEDING LETTERS		
	Measured or Initiating Variable	**Modifier**	**Readout or Passive Function**	**Output Function**	**Modifier**
A	ANALYSIS		ALARM		
B	BURNER FLAME	BY PASS	USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
C	CONDUCTIVITY (ELECTRICAL) OR USER'S CHOICE			CONTROL	
D	DENSITY (MASS) OR SPECIFIC GRAVITY OR USER'S CHOICE	DIFFERENTIAL			
E	VOLTAGE		PRIMARY ELEMENT		
F	FLOW RATE	RATIO (FRACTION)			
G	GAGING (DIMENSIONAL)		GLASS		
H	HAND (MANUALLY INITITATED)				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME OR TIME SCHEDULE			CONTROL STATION	
L	LEVEL		LIGHT (PILOT)		LOW
M	MOISTURE OR HUMIDITY OR USER'S CHOICE				MIDDLE OR INTERMEDIATE
N	USER'S CHOICE		USER'S CHOICE	USER'S CHOICE	USER'S CHOICE
O	USER'S CHOICE		OFFICE (RESTRICTION)		
P	PRESSURE OR VACUUM		POINT (TEST CONNECTION)		
Q	QUANTITY OR EVENT	INTEGRATE OR TOTALIZE			
R	RUN OR RADIOACTIVITY	RATIO	RECORD OR PRINT		
S	SPEED OR FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMITTER	
U	MULTIVARIABLE		MALFUNCTION	MALFUNCTION	MALFUNCTION
V	VISCOSITY OR VIBRATION			LVE, DAMPER, OR LOUVER	
W	WEIGHT OR FORCE		WELL		
X	LOGIC / INTERLOCK		UNCLASSIFIED	LOGIC / INTERLOCK	UNCLASSIFIED OR RECEIVER
Y	USER'S CHOICE, EVENTS			RELAY OR COMPUTE	
Z	POSITION			DRIVER, ACTUATOR, UNCLASSIFIED CONTROL ELEMENT	

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: HR
CHECKED: HR

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

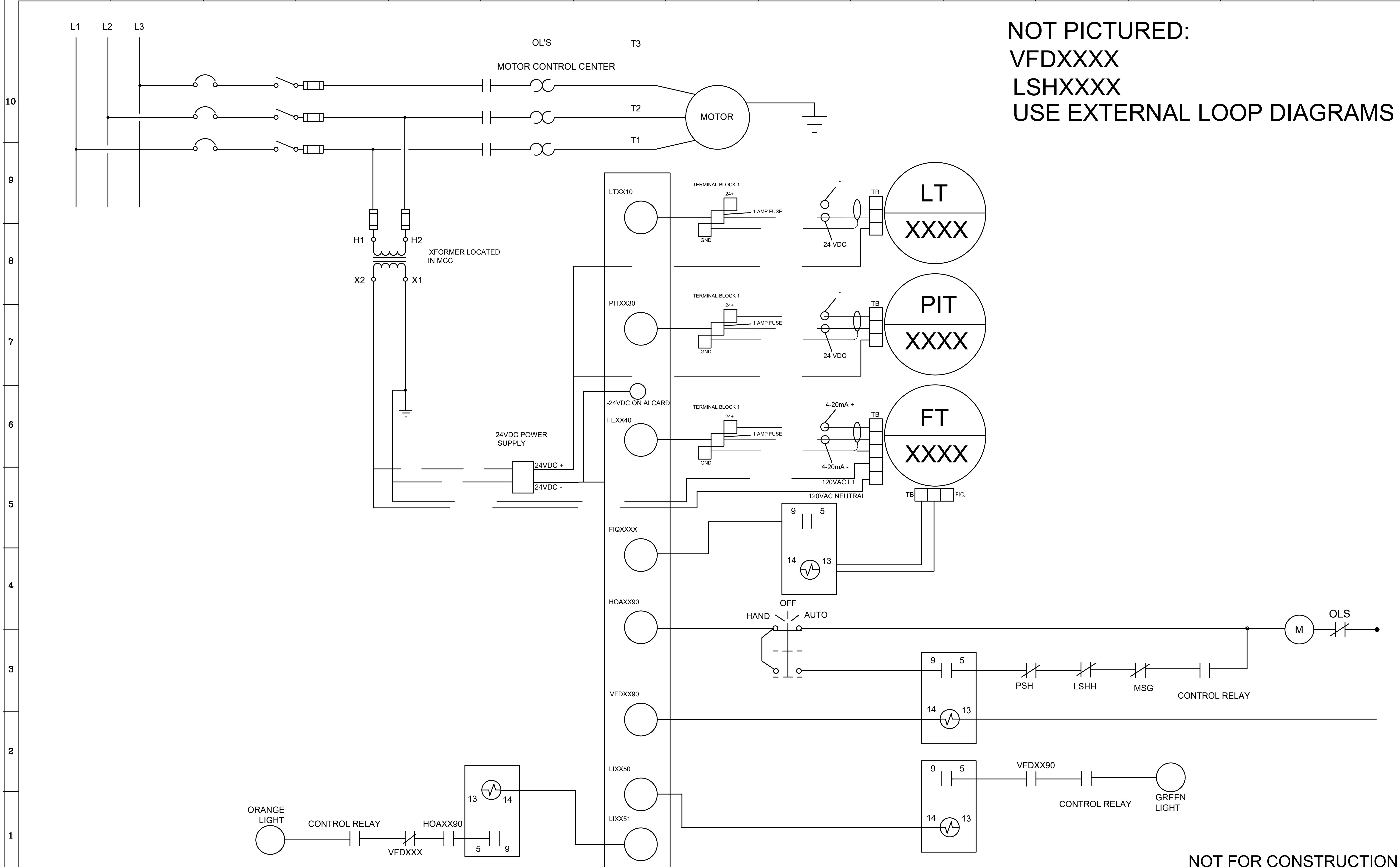
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD
BUNKER HILL PLC
INSTRUMENTATION SYMBOLS & ABBREVIATION

SCALE NONE
DRAWING NUMBER S2
SHEET NUMBER 2 OF 18



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REVISIONS

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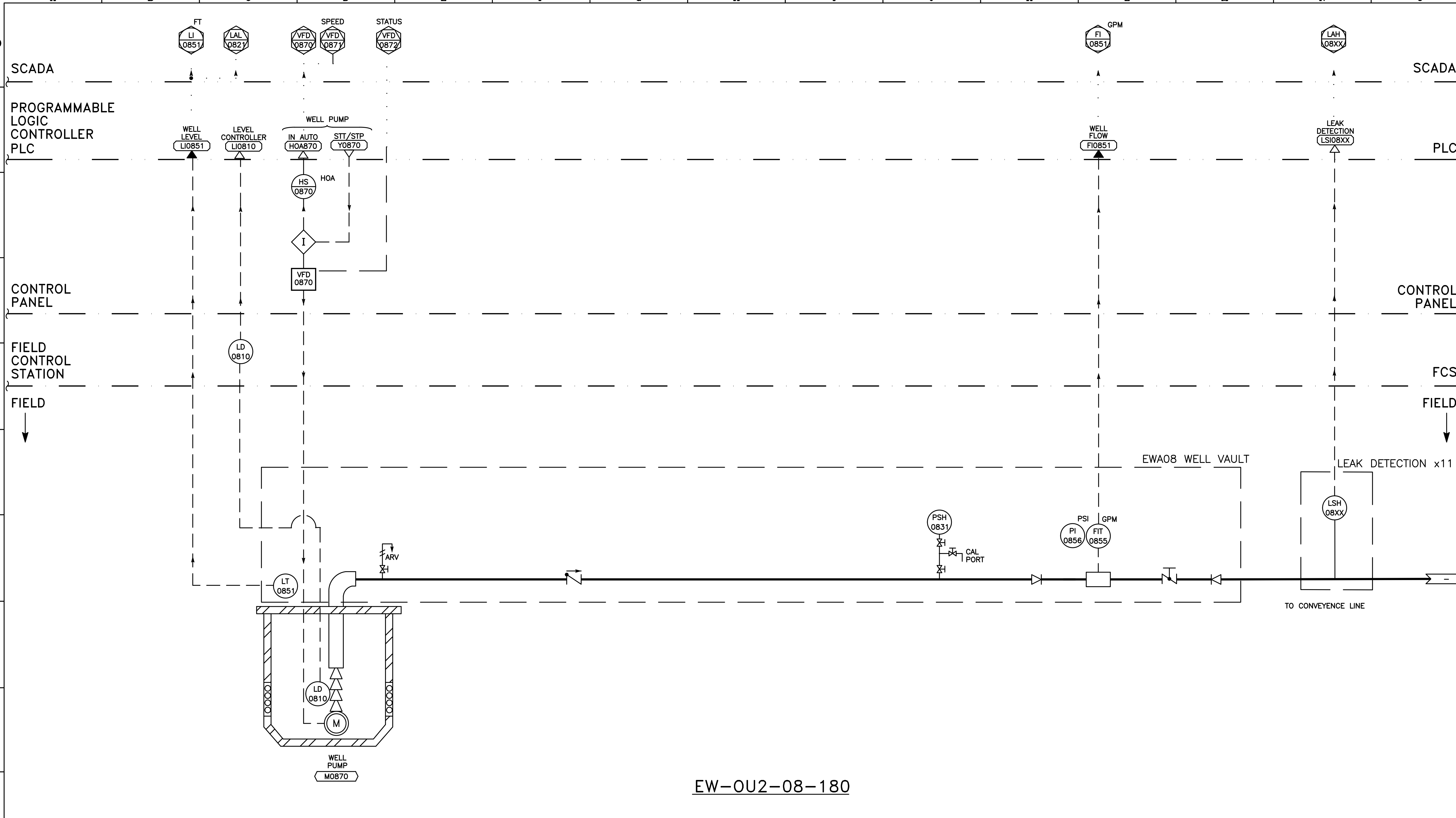
APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
ELEMENTARY DIAGRAM

SCALE: NOT TO SCALE
DRAWING NUMBER: S3
SHEET NUMBER: 3 OF 18



NOT FOR CONSTRUCTION

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DATE: 01/19/2023
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DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

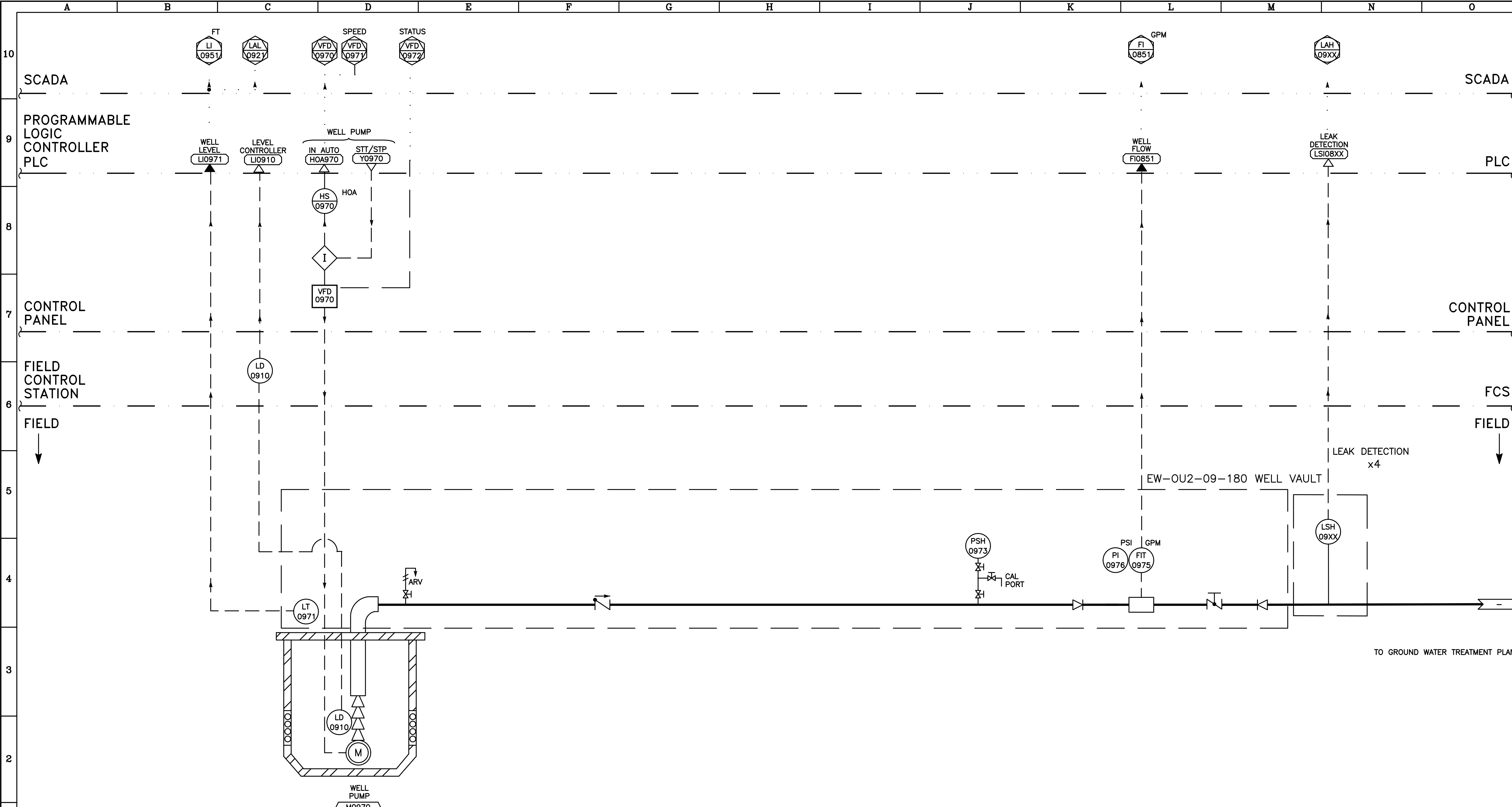
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

APPROVAL RECOMMENDED DATE
APPROVED CONTROL SYSTEMS ENGINEER DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-08-180
P&ID DRAWING

SCALE NONE
DRAWING NUMBER S4
SHEET NUMBER 4 OF 18



EW-OU2-09-180

NOT FOR CONSTRUCTION

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DESIGNED:
CHECKED:

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SUBMITTAL APPROVED: DATE:

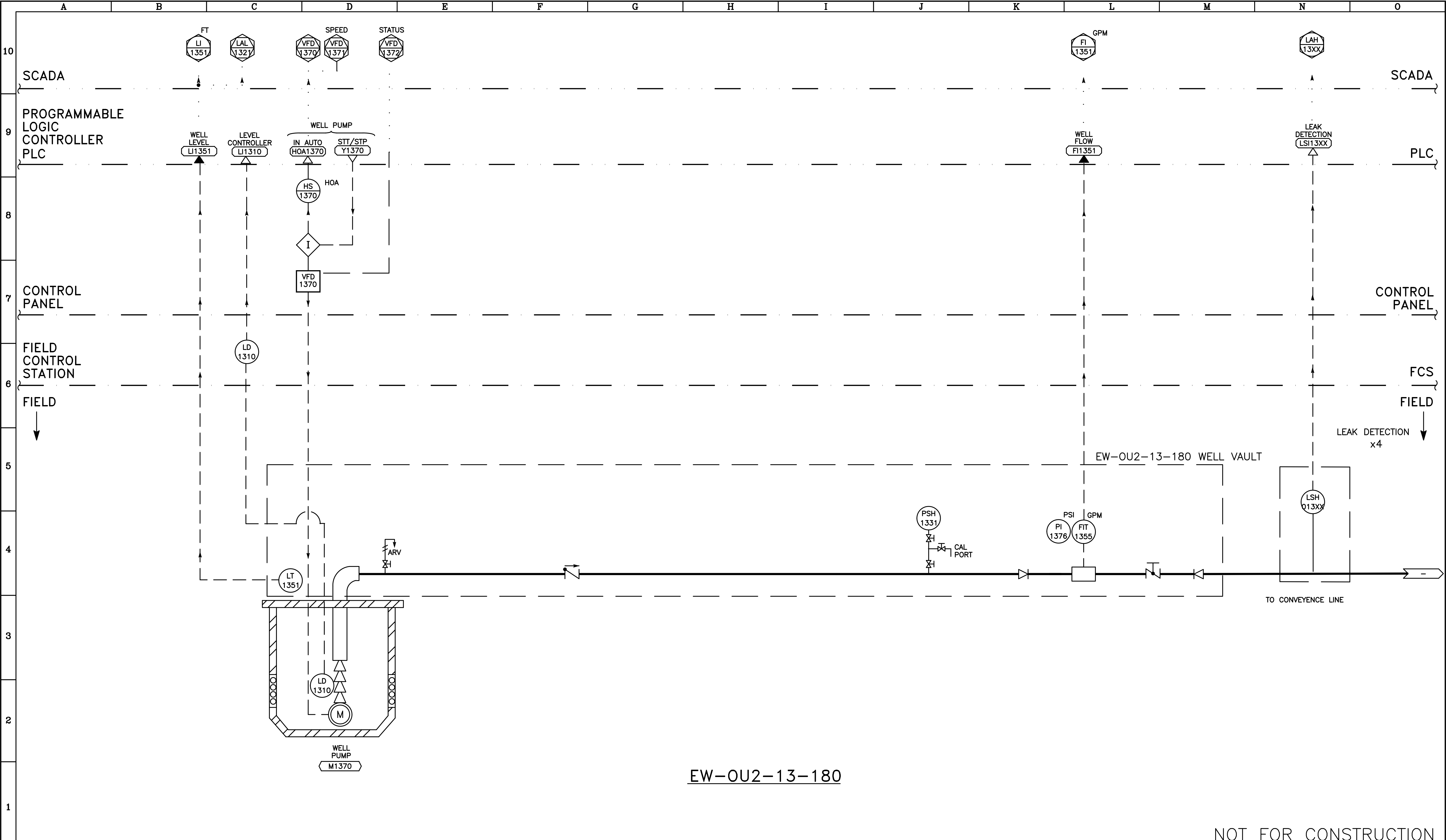
KORE systems Inc

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

APPROVAL RECOMMENDED DATE
APPROVED CONTROL SYSTEMS ENGINEER DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-09-180
P&ID DRAWING

SCALE NONE
DRAWING NUMBER S5
SHEET NUMBER 5 OF 18



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KORE systems inc

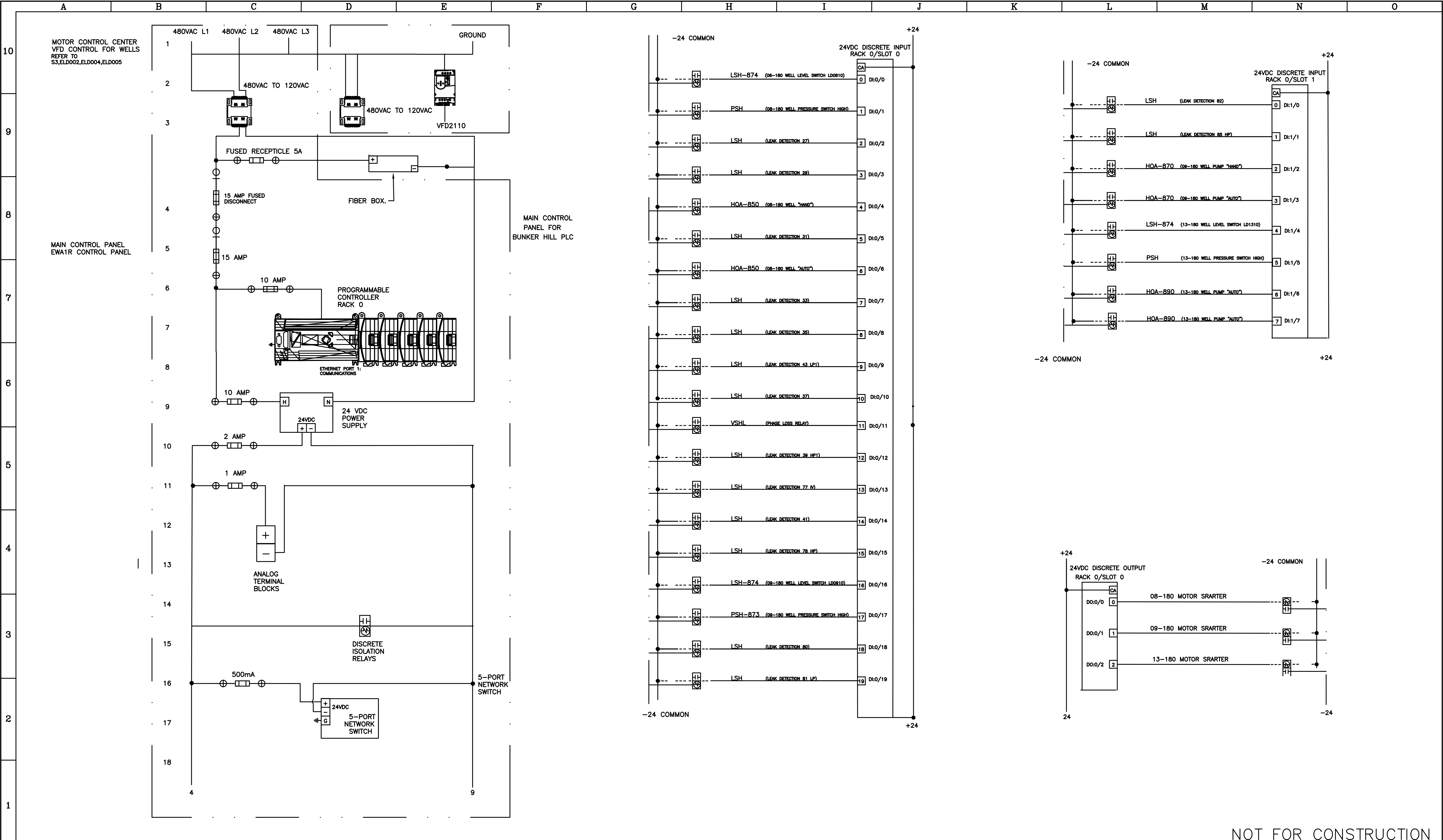
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

APPROVAL RECOMMENDED ______ DATE
APPROVED ______ CONTROL SYSTEMS ENGINEER DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
P&ID DRAWING

SCALE NONE
DRAWING NUMBER S6
SHEET NUMBER 6 OF 18



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KORE systems Inc

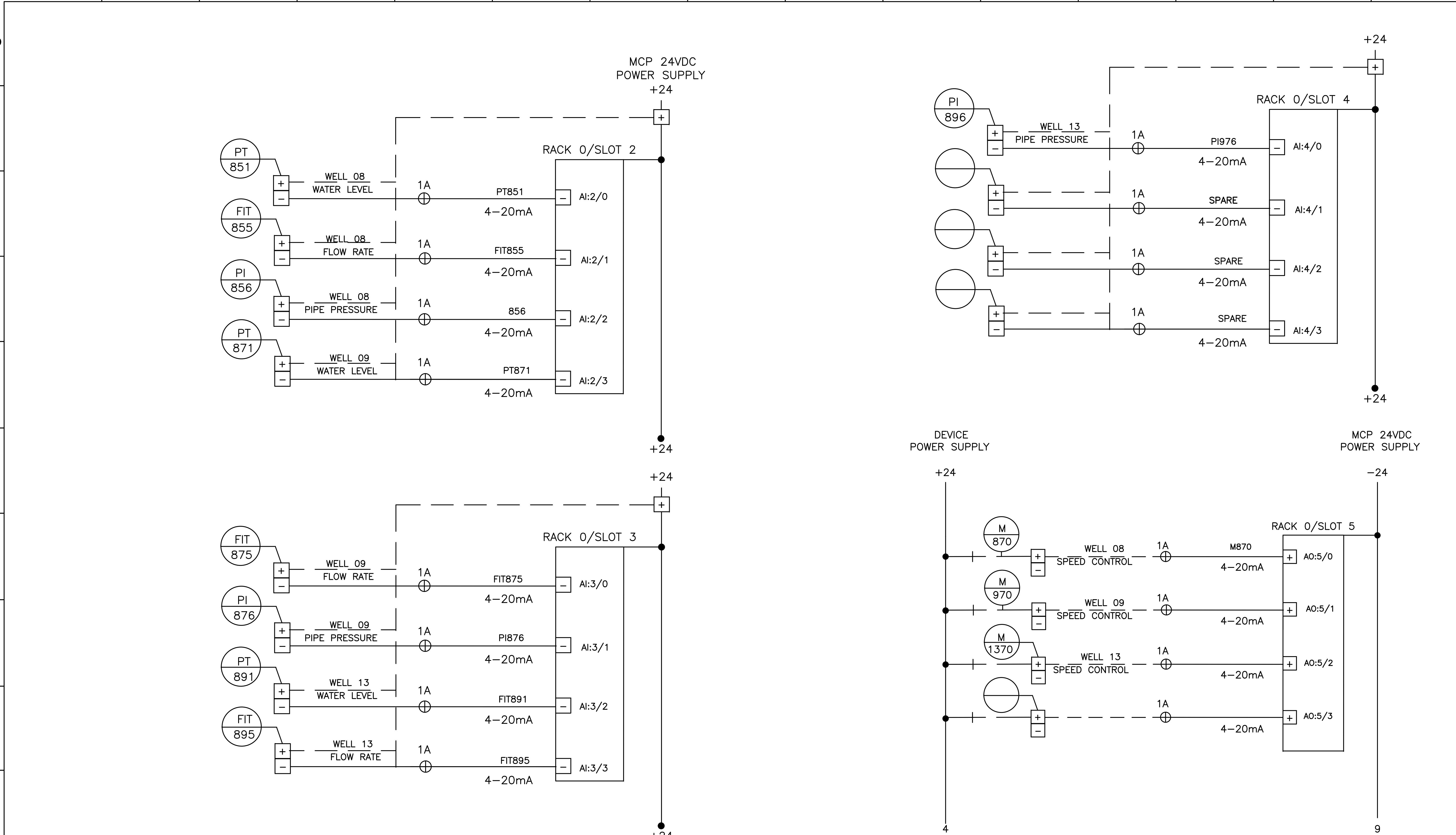
REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ CONTROL SYSTEMS ENGINEER DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
IO SCHEMATIC

SCALE: NONE
DRAWING NUMBER: S7
SHEET NUMBER: 7 OF 18



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DESIGNED:
CHECKED:

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SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	2				

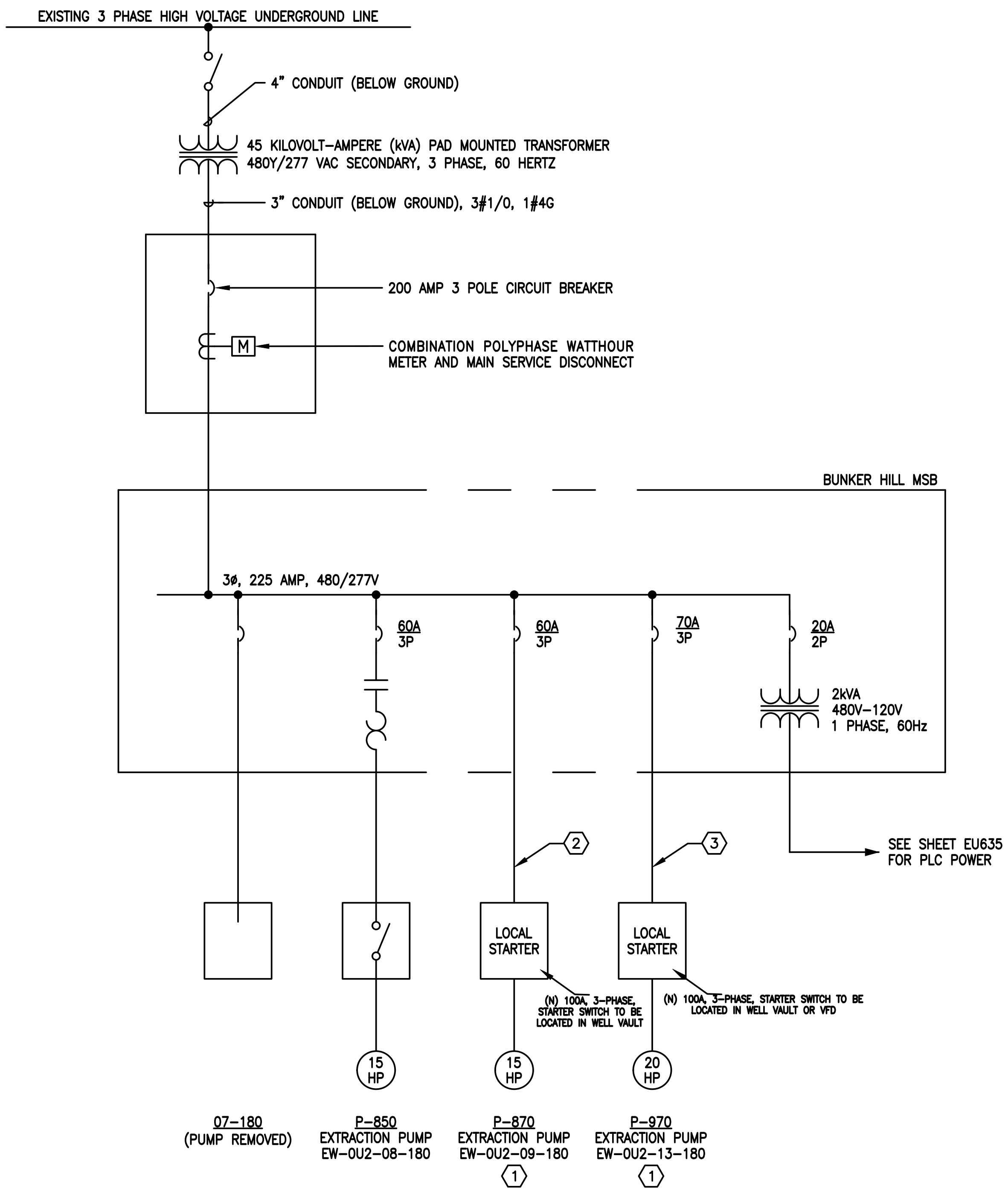
APPROVAL RECOMMENDED ______ DATE
APPROVED ______ CONTROL SYSTEMS ENGINEER DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL PLC
IO SCHEMATIC

SCALE NONE
DRAWING NUMBER S8
SHEET NUMBER 8 OF 18



PLC PANEL LOAD CALCULATOR	LOAD (VA)			
	AØ	BØ	CØ	TOTAL
PLC XFRM (2k XFRM)	1000	1000		60002
EW-OU2-08-180 (15hp motor)	5800	5800	5800	
EW-OU2-09-180 (15hp motor)	5800	5800	5800	
EW-OU2-13-180 (20hp motor)	7734	7734	7734	
Phase Total (VA)	20334	20334	19334	
Phase Balance (%)	33.9%	33.9%	32.2%	
TOTALS	LOAD (VA)	LOAD (A)	LOAD (W)	
Total Demand	60002	72.3	51002	
Total Demand + Spare	75003	90.32	63753	

ASSUMPTIONS

1. THE 2KVA TRANSFORMER USES 2 WIRES OF THE 3-PHASE POWER.
2. NO EXTRA DEVICES/COMPONENTS ARE ATTACHED TO THIS POWER SOURCE.
3. SPARE LOADS INCLUDE EXTRA 25% CAPACITY.
4. POWER FACTOR = 0.85
5. ADDITIONAL 20 HP MOTOR HAS THE SAME POWER EFFICIENCY AS PREVIOUS 15 HP MOTORS.

KEYED NOTES

1. EXTRACTION PUMP SHALL BE FITTED WITH A TEMPERATURE SENSOR, RUN SENSOR WIRES FROM LOCAL STARTER BOX TO VAULT LOW-VOLTAGE CONTROL ENCLOSURE AND WIRE TO MOTOR PROTECTION UNIT THAT IS ALSO INSTALLED IN ENCLOSURE, REFER TO PUMP MANUFACTURER INSTALLATION INSTRUCTIONS.
2. (N) CONDUCTORS IN (E) CONDUIT, VERIFY EXTRACTION PUMP HP & WIRING PRIOR TO INSTALLING (N) CONDUCTORS.
3. (N) CONDUCTORS IN (E) CONDUIT, VERIFY EXTRACTION PUMP HP & WIRING PRIOR TO INSTALLING (N) CONDUCTORS.

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

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CHECKED:

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SUBMITTAL APPROVED: DATE:

KORE systems Inc

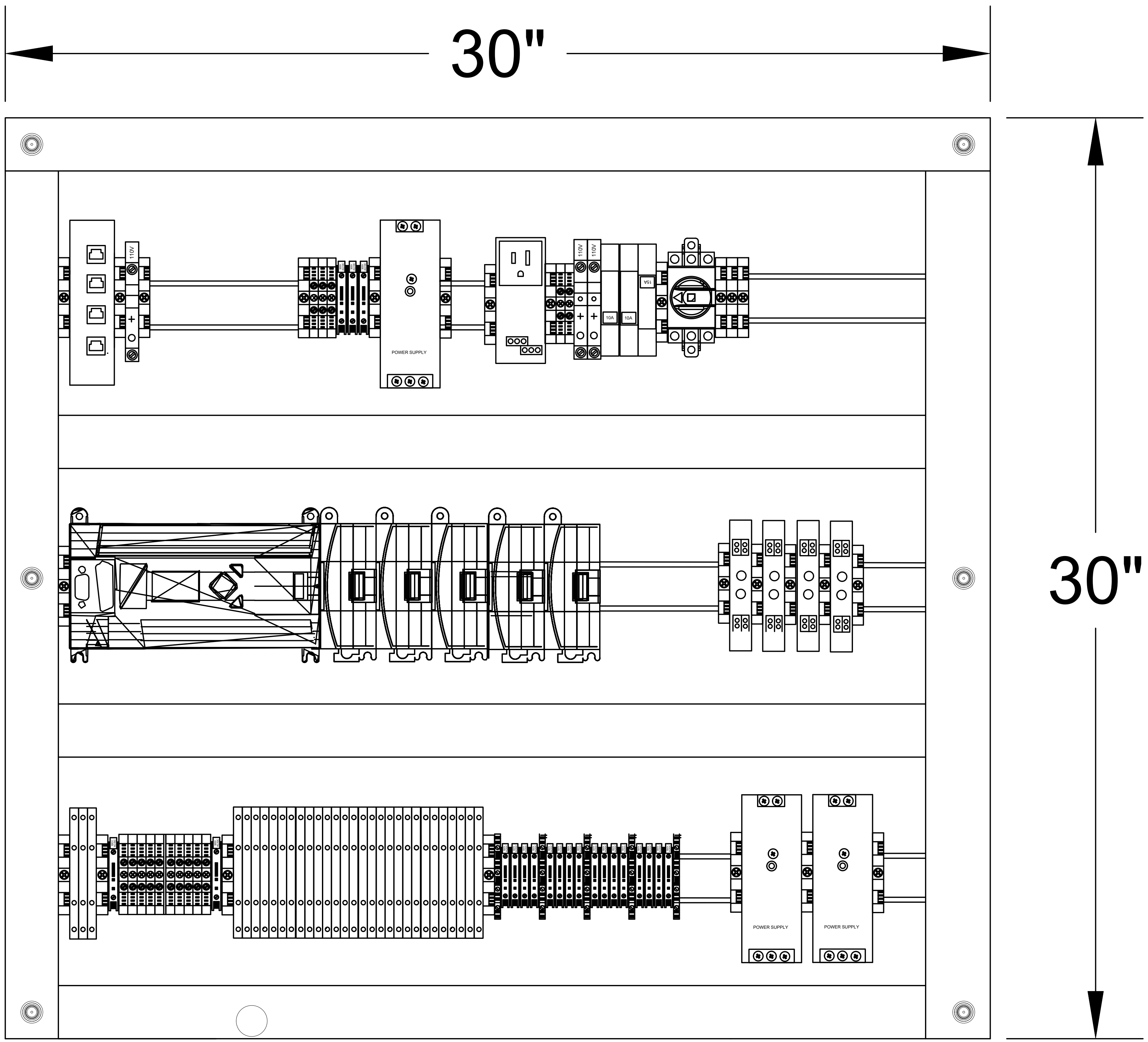
REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

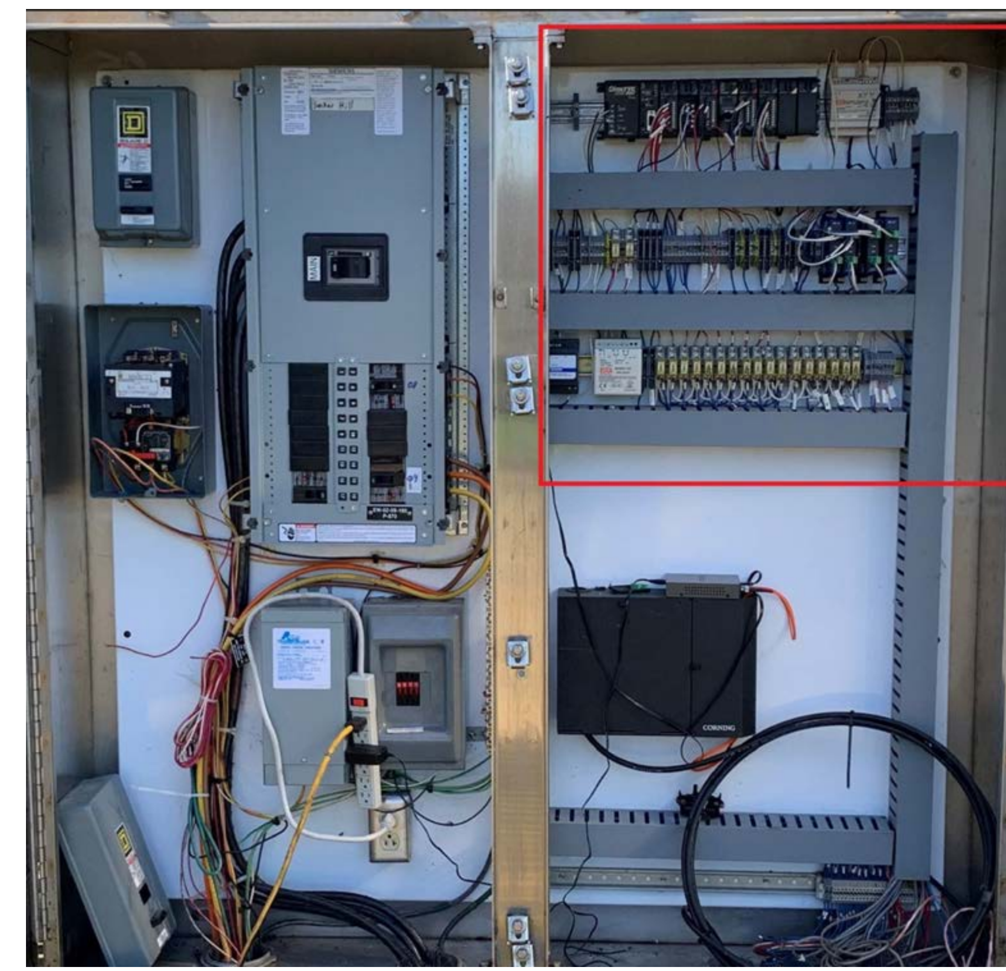
APPROVAL RECOMMENDED: DATE
APPROVED: DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
ONE LINE DRAWING

SCALE NONE
DRAWING NUMBER S9
SHEET NUMBER 9 OF 18

NOTE: PANEL DRAWING IS FOR BACK PANEL REPLACEMENT OF THE SECTION REDLINED BELOW





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FILE:
DRAWN: FV
DESIGNED:
CHECKED:

SUBMITTED: DATE:
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KORE systems Inc

REVISIONS

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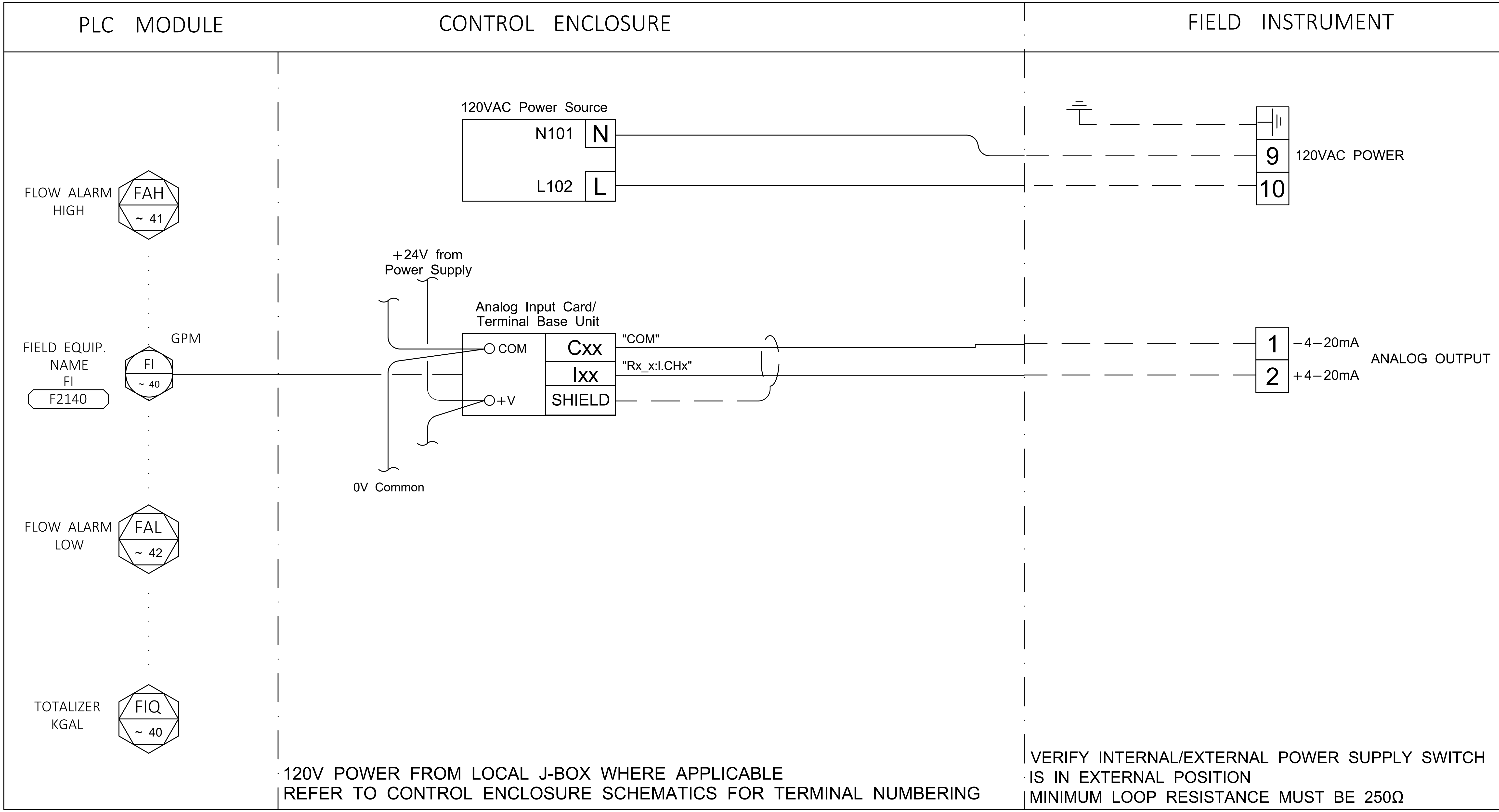
APPROVAL RECOMMENDED ______ DATE
APPROVED ______ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL PLC
INTERNAL PANEL LAYOUT

SCALE: NONE
DRAWING NUMBER: S10
SHEET NUMBER: 10 OF 18



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KORE systems Inc

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APPROVAL RECOMMENDED DATE
APPROVED DATE

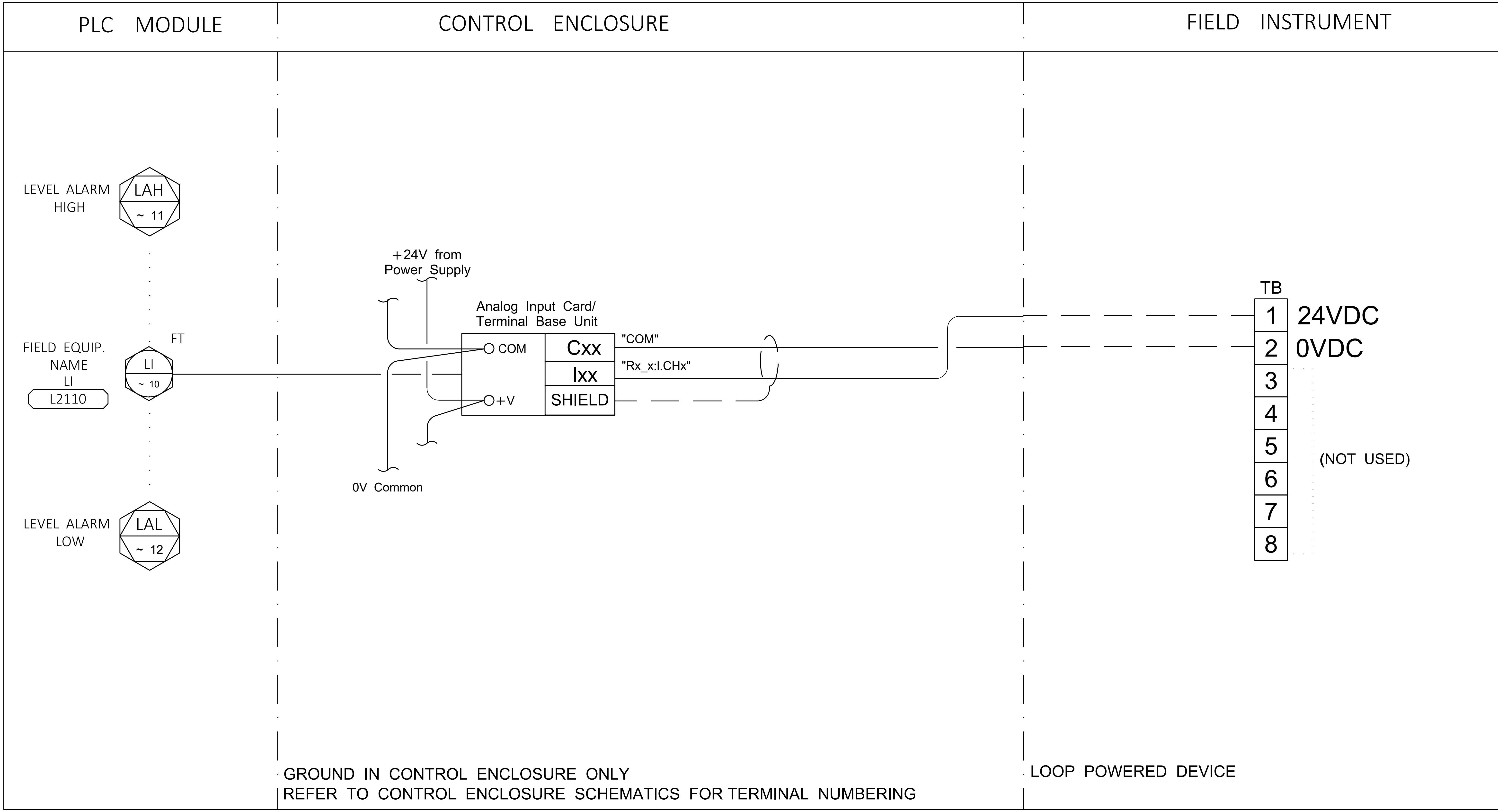
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
FLOW INSTRUMENT DIAGRAM

SCALE
NONE

DRAWING NUMBER
ELD01

SHEET NUMBER
11 OF 18



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KORE systems Inc

REVISIONS

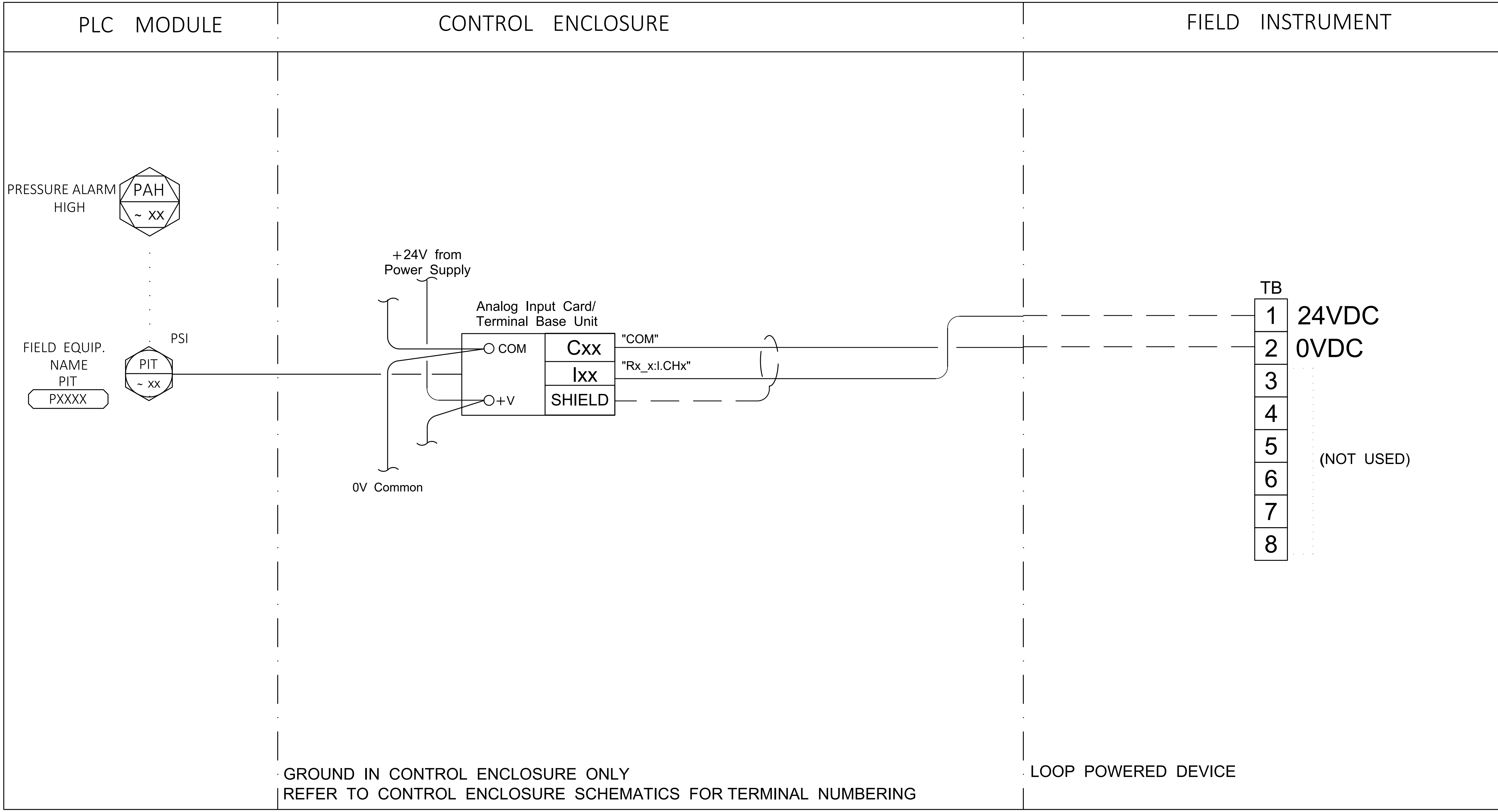
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
LEVEL INSTRUMENT DIAGRAM

SCALE NONE
DRAWING NUMBER ELD02
SHEET NUMBER 12 OF 18



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REVISIONS

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APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
BUNKER HILL PLC
PRESSURE INSTRUMENT DIAGRAM

SCALE: NONE
DRAWING NUMBER: ELD03
SHEET NUMBER: 13 OF 18

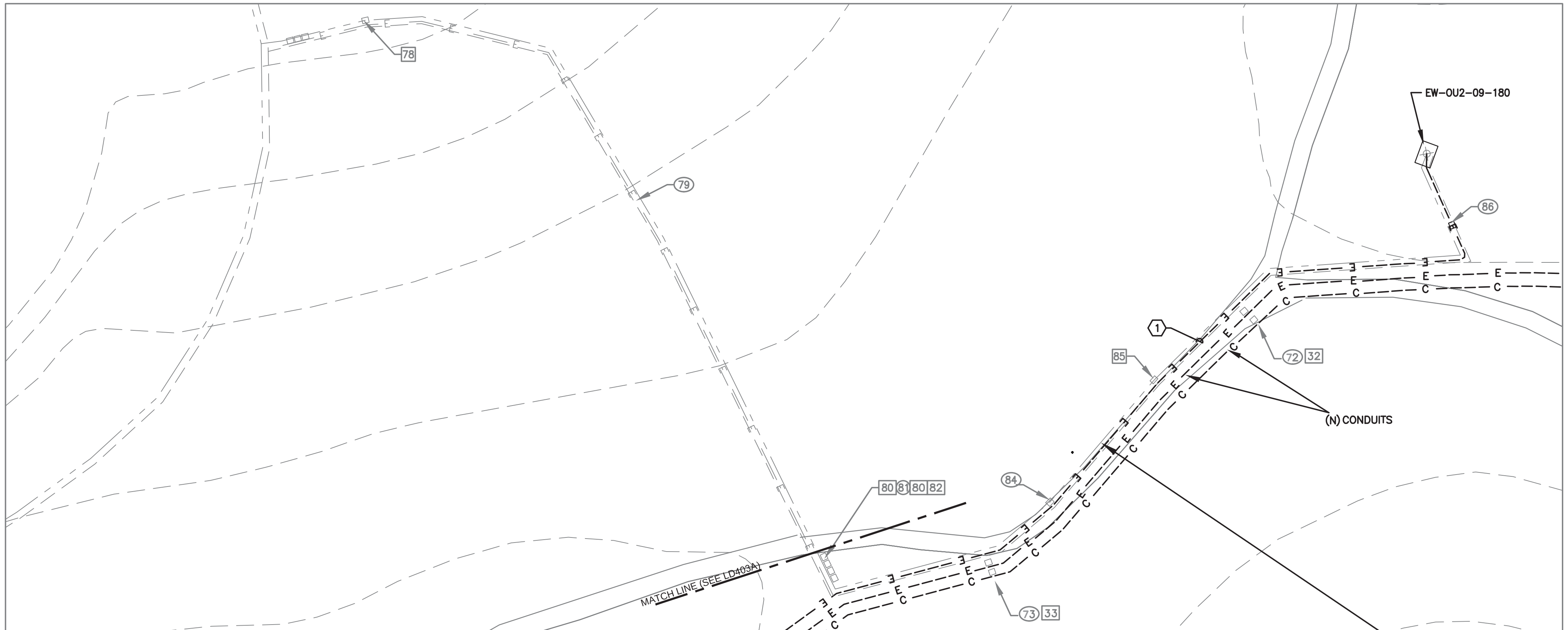
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

GENERAL NOTES

1. FOR ALL (N) UNDERGROUND METALLIC STRUCTURES PROVIDE CORROSION PROTECTION. THE CONTRACTOR MAY MODIFY THE CATHODIC PROTECTION SYSTEM AS SHOWN IN DETAILS ON E-504 AFTER SITE VERIFICATION AND ANALYSIS.
2. FOR TRAFFIC AND NON-TRAFFIC HANDHOLES SEE DETAIL 1 ON IU501 AND DETAIL 13 ON E-502.
3. SEE CU SHEETS FOR ADDITIONAL TRENCH PROFILES AND DETAILS.

KEYED NOTES

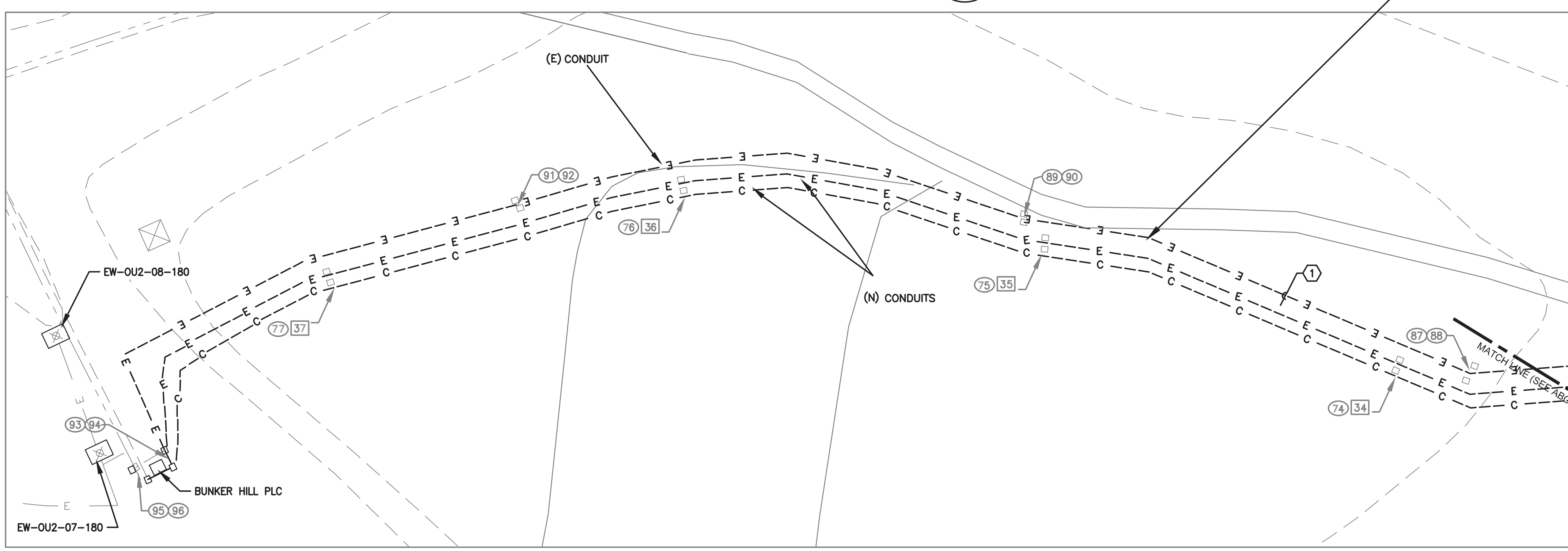
~~1 (N) CONDUCTORS IN (E) CONDUITS.~~



(E) NO CONTROL CONDUCTORS

1 BUNKER HILL NETWORK

SCALE 1 : 30



2 BUNKER HILL NETWORK

SCALE 1 : 30

30 0 30 60

GRAPHIC SCALE IN FEET

KEY PLAN

NOT FOR CONSTRUCTION – PENDING FIELD REVIEW – ALL LENGTHS APPROXIMATE

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)	DATE: 01/25/2023 FILE: DRAWN: HR DESIGNED: CHECKED:
SUBMITTED:	DATE:
SUBMITTAL APPROVED:	DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1				
	2				
	3				
	4				

APPROVAL RECOMMENDED ____ DATE

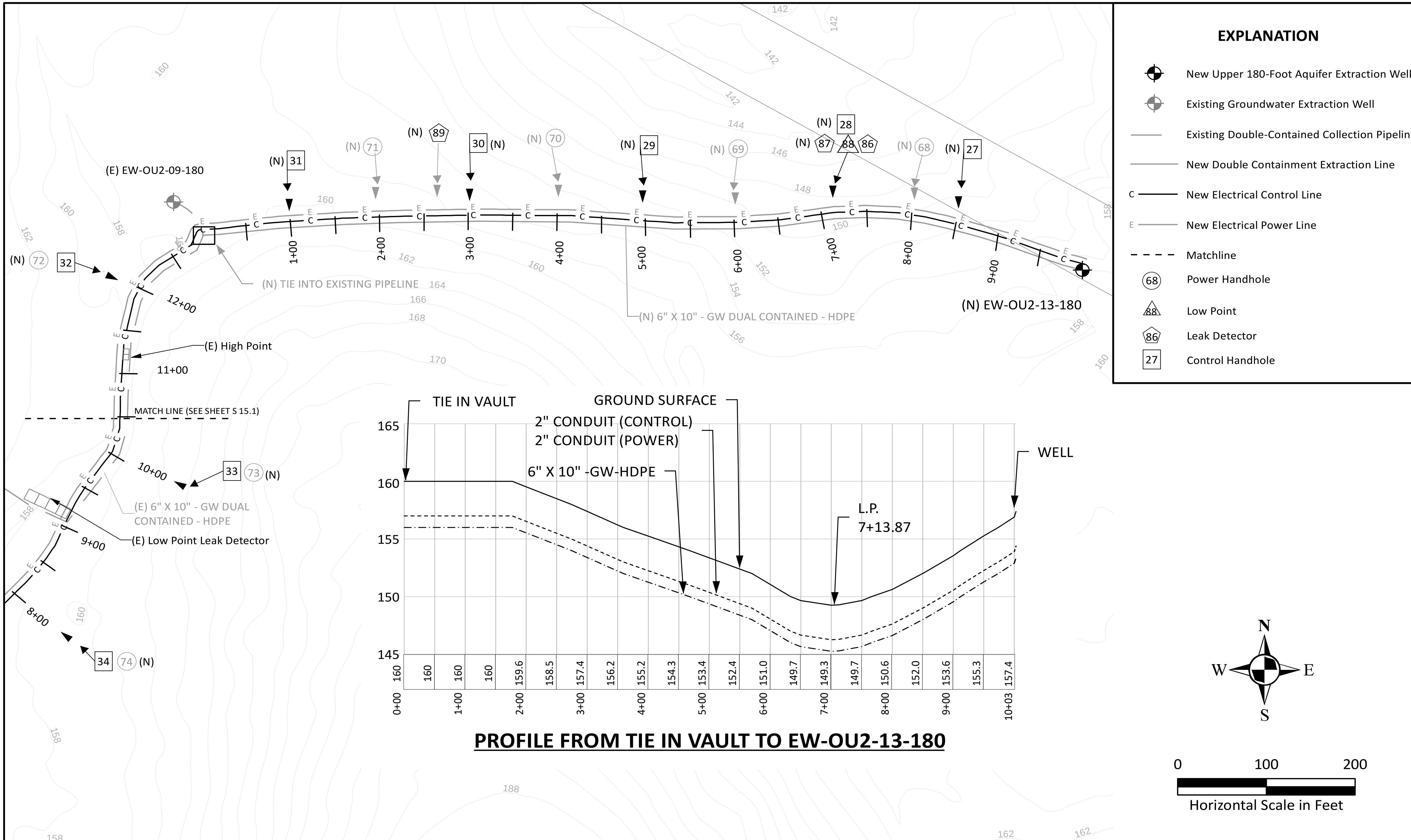
APPROVED ____ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
CONDUIT ROUTING

SCALE
NOT TO SCALE
DRAWING NUMBER
S14
SHEET NUMBER
14 OF 18



NOT FOR CONSTRUCTION — PENDING FIELD REVIEW — ALL LENGTHS APPROXIMATE

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

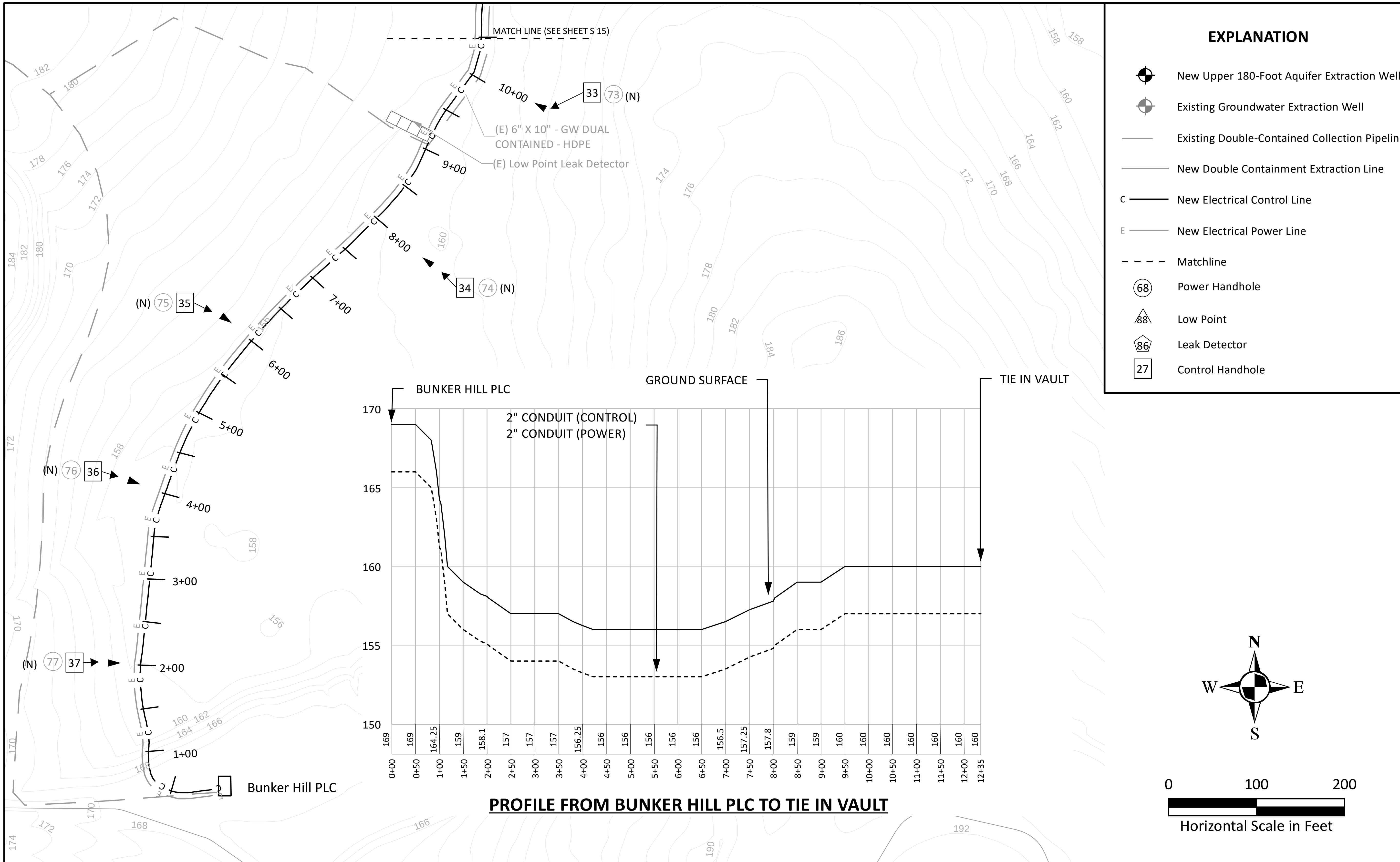
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA

EW-OU2-13-180
CONDUIT ROUTING

SCALE NONE
DRAWING NUMBER S15
SHEET NUMBER 15 OF 18



PROFILE FROM BUNKER HILL PLC TO TIE IN VAULT

NOT FOR CONSTRUCTION – PENDING FIELD REVIEW – ALL LENGTHS APPROXIMATE

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"–SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

REVISIONS

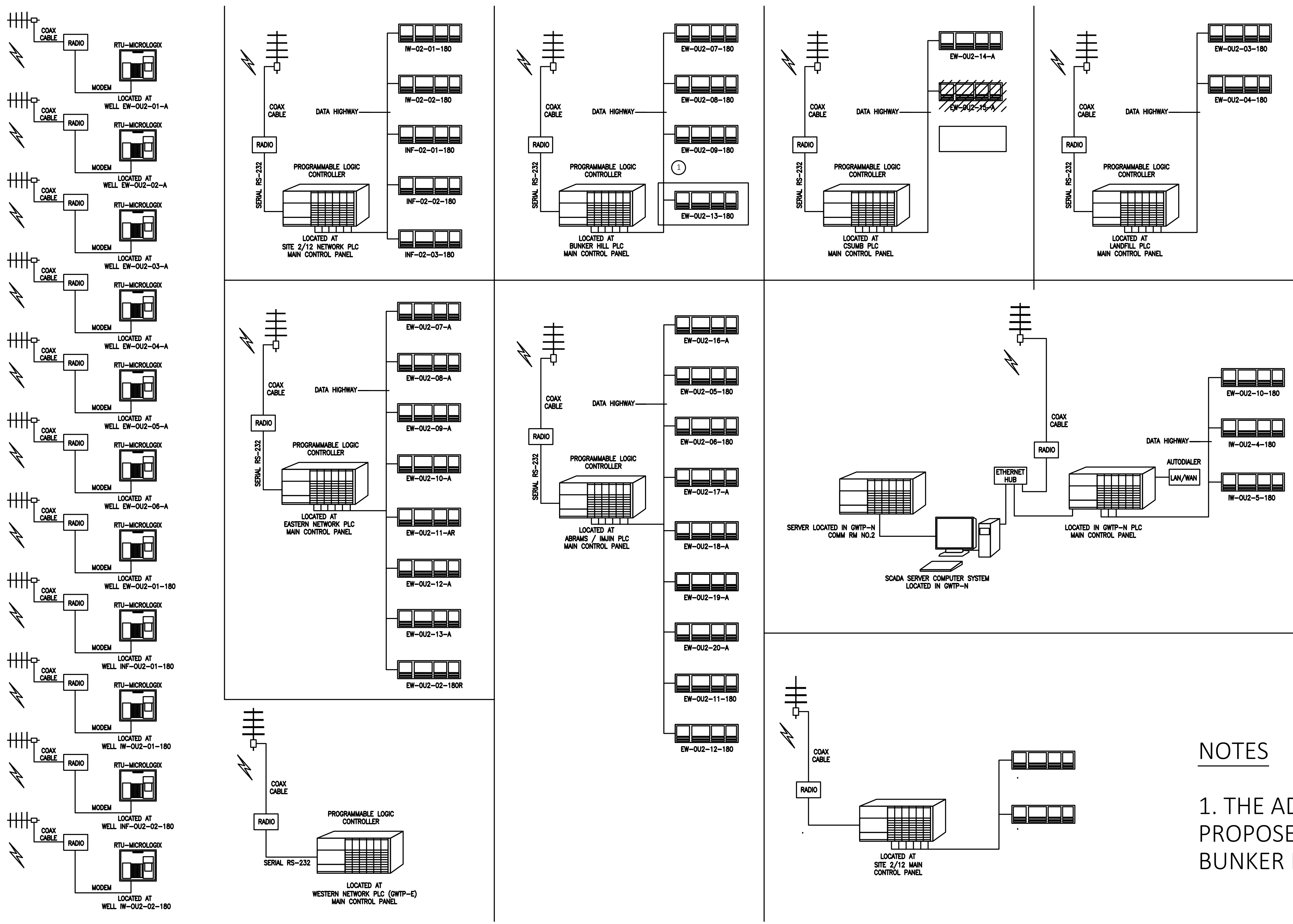
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW–OU2–13–180
CONDUIT ROUTING

SCALE NONE
DRAWING NUMBER S15.1
SHEET NUMBER 15 OF 18

A B C D E F G H I J K L M N O



NOTES

1. THE ADDITION OF THE NEW PROPOSED EXTRACTION WELL AT BUNKER HILL.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE:
FILE:
DRAWN:
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL RECOMMENDED ____ DATE
APPROVED ____ DATE

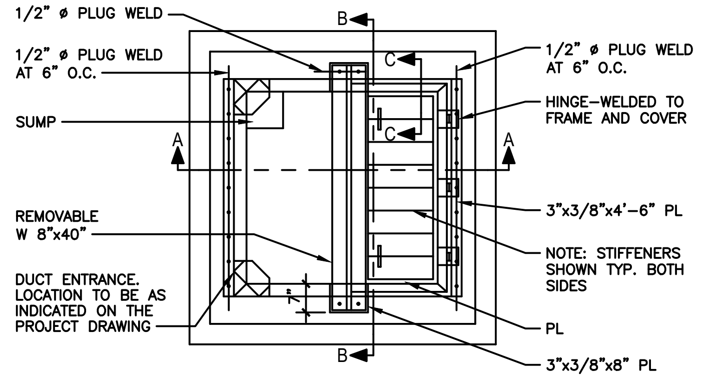
CONTRACT NUMBER

AHTNA GLOBAL, LCC
FORT ORD, CA
BUNKER HILL PLC
COMMUNICATION HUB

SCALE NONE

DRAWING NUMBER S16

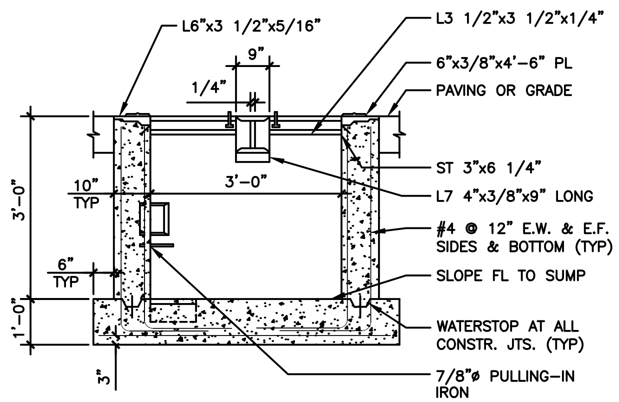
SHEET NUMBER 16 OF 18



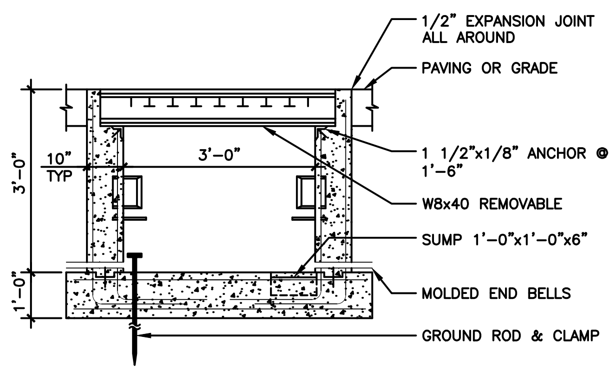
PLAN

NOTES:

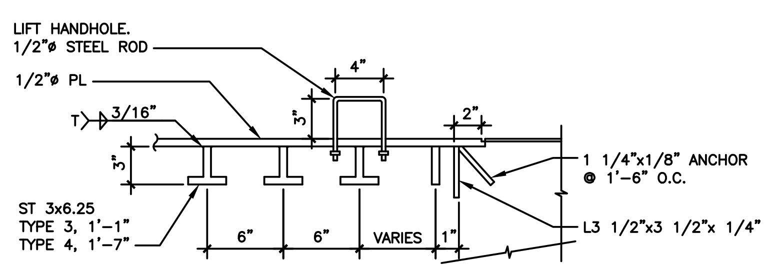
1. ENTRANCE OF DUCTS INTO HANDHOLE MAY BE MADE ON SIDE FACES OR CORNERS AS REQUIRED.
2. FOR DETAILS OF CABLE RACKS, DUCT ENTRANCE AND PULLING-IN IRONS, SEE DETAIL 3, IU501.
3. HANDHOLE AND COVER IS DESIGNED FOR MAXIMUM SINGLE WHEEL LOAD OF 25,000 LB.
4. COVER SHALL BE MADE OF STRUCTURAL STEEL CONFORMING TO ASTM A 36/A 36M.
5. MINIMUM COMPRESSIVE STRENGTH OF CONCRETE SHALL BE 3000 PSI.



SECTION A-A



SECTION B-B



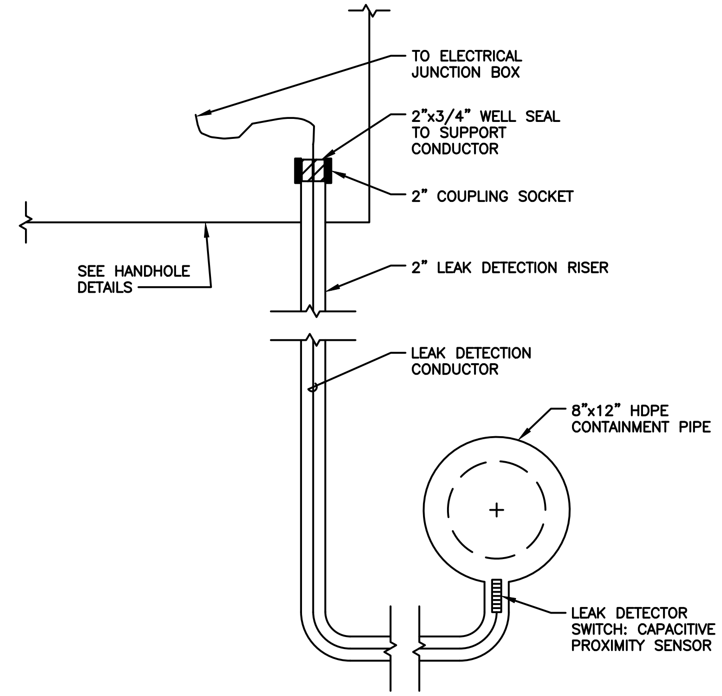
(SEE NOTE 4)

SECTION C-C

1 STANDARD ELECTRICAL/CONTROL HANDHOLE TRAFFIC RATED

NOT TO SCALE

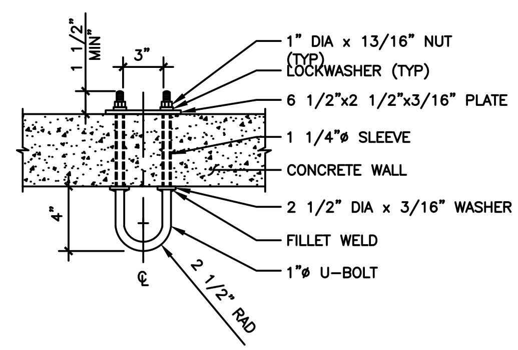
EU401 TO EU408 | IU501
IU101
IU401 TO IU408



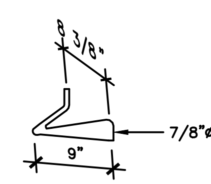
CROSS SECTION

2 LEAK DETECTION STATION

IU406 | IU501 NOT TO SCALE



ALTERED METHOD



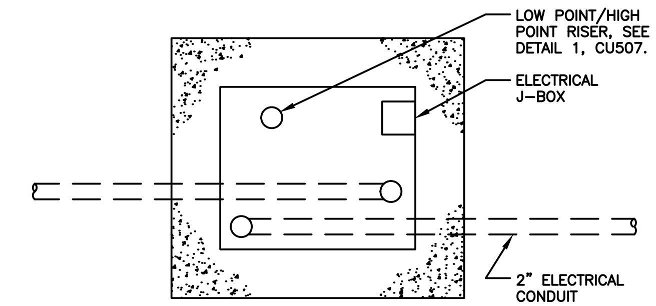
CAST IN PLACE

NOTE:

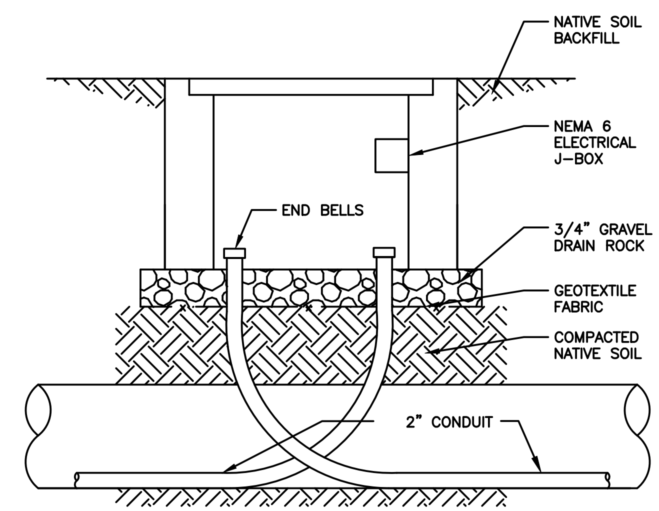
ALL METAL PARTS SHALL BE HOT DIP GALVANIZED

3 PULLING-IN IRON

IU501 | IU501 NOT TO SCALE



PLAN VIEW



CROSS SECTION

NOTES:

1. REFER TO DETAIL 1, THIS PAGE FOR TRAFFIC RATED HANDHOLES OR DETAIL 13, E-502 FOR NON TRAFFIC RATED, AS CONDITIONS DICTATE.

4 HANDHOLE FOR LEAK DETECTION

NOT TO SCALE

IU403 | IU501
IU404

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED:
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

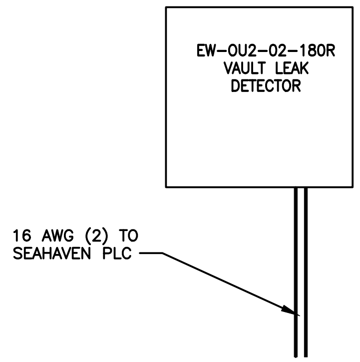
ZONE	REV.	DESCRIPTION	BY	DATE	APP.
1					
2					
3					
4					

APPROVAL RECOMMENDED DATE
APPROVED DATE
CONTRACT NUMBER

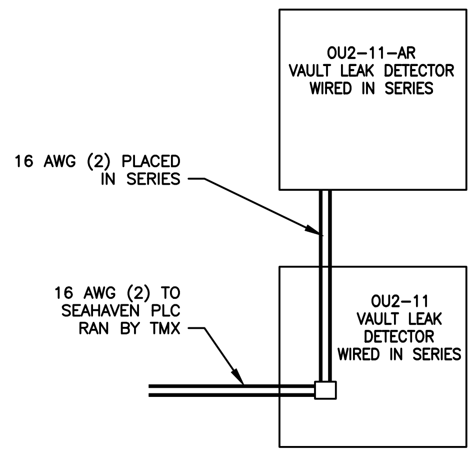
AHTNA GLOBAL, LLC
FORT ORD, CA

BUNKER HILL NETWORK
LEAK DETECTION DETAILS

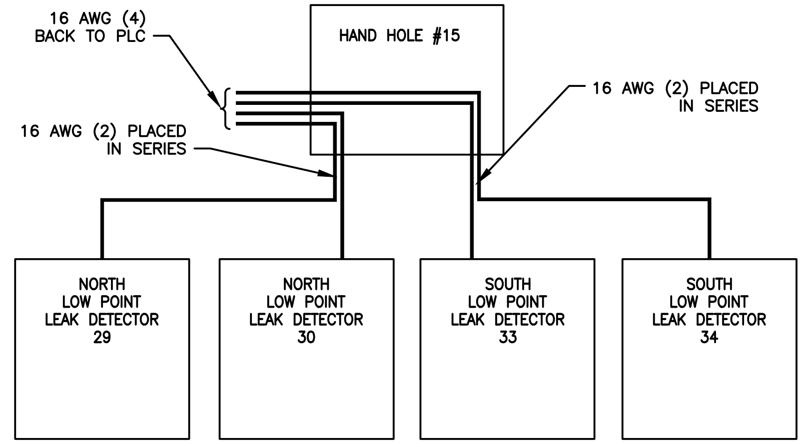
SCALE: NOT TO SCALE
DRAWING NUMBER: S17
SHEET NUMBER: 17 OF 18



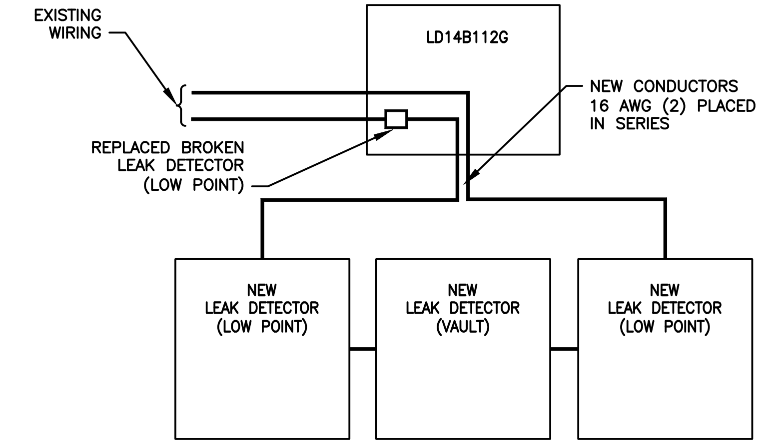
1 CONNECTION SCHEMATIC
LD402 | LD501 NOT TO SCALE



2 CONNECTION SCHEMATIC
LD402 | LD501 NOT TO SCALE

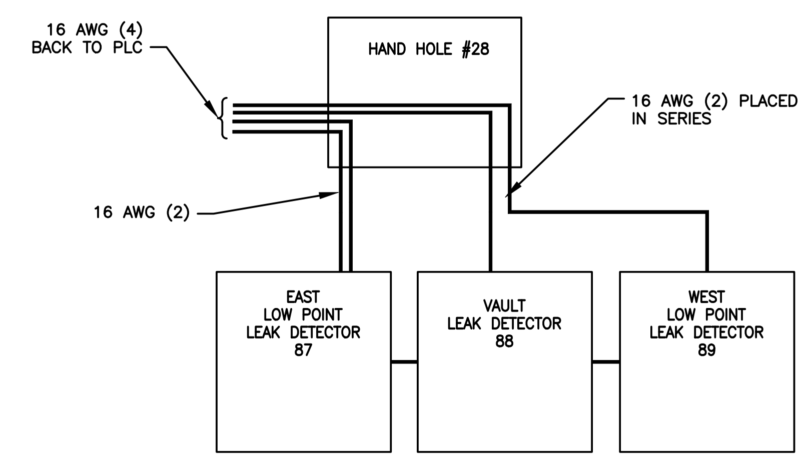


3 CONNECTION SCHEMATIC
LD406 | LD501 NOT TO SCALE

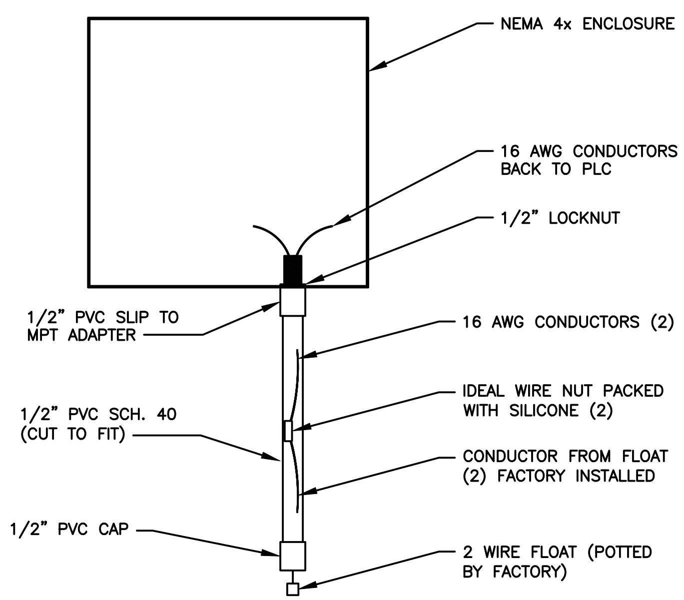


4 CONNECTION SCHEMATIC
LD407 | LD501 NOT TO SCALE

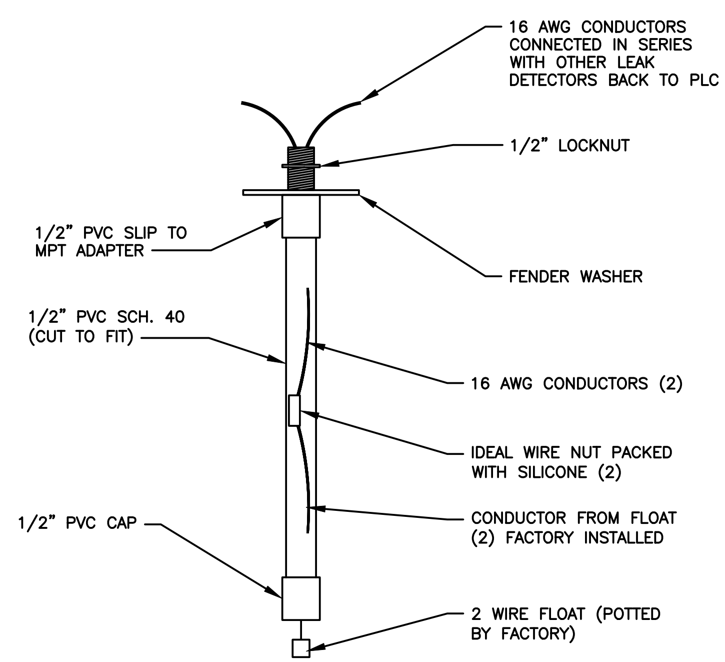
1



7 CONNECTION SCHEMATIC
LD403 | LD501 NOT TO SCALE



5 TYPICAL VAULT LEAK DETECTOR SCHEMATIC
LD501 | LD501 NOT TO SCALE



6 TYPICAL LOW POINT PIPE LEAK DETECTOR SCHEMATIC
LD501 | LD501 NOT TO SCALE

NOTES

1. THE PROPOSED LEAK DETECTORS FOR THE NEW EXTRACTION WELL OU2-13-180.

NOT FOR CONSTRUCTION

LINE IS 2 INCHES AT FULL SIZE
(IF NOT 2"-SCALE ACCORDINGLY)

DATE: 01/25/2023
FILE:
DRAWN: HR
DESIGNED: AHTNA
CHECKED:

SUBMITTED: DATE:
SUBMITTAL APPROVED: DATE:

KORE systems Inc

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

APPROVAL
RECOMMENDED ______ DATE
APPROVED ______ DATE

CONTRACT NUMBER

AHTNA GLOBAL, LLC
FORT ORD, CA
EW-OU2-13-180
LEAK DETECTION SCHEMATIC

SCALE
NONE
DRAWING NUMBER
S18
SHEET NUMBER
18 OF 18

Attachment D:
Design Specifications[8]

[8] Design specifications will be finalized in consultation with subcontracted construction trades and subject matter experts. The actual design and construction of EW-OU2-13-180 and associated equipment are subject to modification based on field conditions encountered and will be described as QAPP Addendum deviations in the Completion Report.

SECTION 01 33 00: SUBMITTAL PROCEDURES
08/18, CHG 4: 02/21

PART 1 GENERAL

1.1 SUMMARY

1.1.1 Submittal Information

Each submittal is to be complete and in sufficient detail to allow ready determination of compliance with contract requirements.

Units of weights and measures used on all submittals are to be the same as those used in the contract drawings.

1.1.2 Project Type

The Subcontractor/Supplier is to check and approve all items before submittal and stamp, sign, and date indicating action taken. Proposed deviations from the contract requirements are to be clearly identified. Include within submittals items such as: Subcontractor's, manufacturer's, or fabricator's drawings; descriptive literature including (but not limited to) catalog cuts, diagrams, operating charts or curves; test reports; test cylinders; samples; O&M manuals (including parts list); certifications; warranties; and other such required submittals.

1.1.3 Submission of Submittals

Schedule and provide submittals requiring approval before acquiring the material or equipment covered thereby. Pick up and dispose of samples not incorporated into the work in accordance with manufacturer's Safety Data Sheets (SDS) and in compliance with existing laws and regulations.

1.2 DEFINITIONS

1.2.1 Submittal Descriptions (SD)

Submittal requirements are specified in the technical sections. Examples and descriptions of submittals identified by the Submittal Description (SD) numbers and titles follow:

SD-01 Preconstruction Submittals

Submittals that are required prior to or commencing with the start of work on site. Submittals that are required prior to or at the start of construction (work) or the next major phase of the construction on a multiphase contract.

Preconstruction Submittals include schedules and a tabular list of locations, features, and other pertinent information regarding products, materials, equipment, or components to be used in the work.

Certificates Of Insurance

Surety Bonds

List Of Proposed Subcontractors

List Of Proposed Products

Baseline Network Analysis Schedule (NAS)

Submittal Register

Schedule Of Prices Or Earned Value Report

Accident Prevention Plan;

Quality Assurance Project Plan

Work Plan

Quality Control (QC) plan

Environmental Protection Plan

Permits

SD-02 Shop Drawings

Drawings, diagrams and schedules specifically prepared to illustrate some portion of the work.

Diagrams and instructions from a manufacturer or fabricator for use in producing the product and as aids to the Subcontractor for integrating the product or system into the project.

Drawings prepared by or for the Subcontractor to show how multiple systems and interdisciplinary work will be coordinated.

SD-03 Product Data

Catalog cuts, illustrations, schedules, diagrams, performance charts, instructions and brochures illustrating size, physical appearance and other characteristics of materials, systems or equipment for some portion of the work.

Samples of warranty language when the contract requires extended product warranties.

SD-04 Samples

Fabricated or unfabricated physical examples of materials, equipment or workmanship that illustrate functional and aesthetic characteristics of a material or product and establish standards by which the work can be judged.

Color samples from the manufacturer's standard line (or custom color samples if specified) to be used in selecting or approving colors for the project.

Field samples and mock-ups constructed on the project site establish standards ensuring work can be judged. Includes assemblies or portions of assemblies that are to be incorporated into the project and those that will be removed at conclusion of the work.

SD-06 Test Reports

Report signed by authorized official of testing laboratory that a material, product or system identical to the material, product or system to be provided has been tested in accord with specified requirements. Unless specified in another section, testing must have been within three years of date of contract award for the project.

Report that includes findings of a test required to be performed on an actual portion of the work or prototype prepared for the project before shipment to job site.

Report that includes finding of a test made at the job site or on sample taken from the job site, on portion of work during or after installation.

Investigation reports Daily logs and checklists

Final acceptance test and operational test procedure

SD-07 Certificates

Statements printed on the manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that the product, system, or material meets specification requirements. Must be dated after award of project contract and clearly name the project.

Document required of Subcontractor, or of a manufacturer, supplier, installer or Subcontractor through Contractor. The document purpose is to further promote the orderly progression of a portion of the work by documenting procedures, acceptability of methods, or personnel qualifications.

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system or material, including special notices and (SDS)concerning impedances, hazards and safety precautions.

SD-09 Manufacturer's Field Reports

Documentation of the testing and verification actions taken by manufacturer's representative at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation, to confirm compliance with manufacturer's standards or instructions. The documentation must be signed by an authorized official of a testing laboratory or agency and state the test results; and indicate whether the material, product, or system has passed or failed the test.

Factory test reports.

SD-10 Operation and Maintenance Data

Data provided by the manufacturer, or the system provider, including manufacturer's help and product line documentation, necessary to maintain and install equipment, for operating and maintenance use by facility personnel.

Data required by operating and maintenance personnel for the safe and efficient operation, maintenance and repair of the item.

Data incorporated in an operations and maintenance manual or control system.

SD-11 Closeout Submittals

Documentation to record compliance with technical or administrative requirements or to establish an administrative mechanism.

Special requirements necessary to properly close out a construction contract. For example, Record Drawings and as-built drawings. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1.2.2 Approving Authority

Office or designated person authorized to approve the submittal.

1.2.3 Work

As used in this section, on-site and off-site construction required by contract documents, including labor necessary to produce submittals, construction, materials, products, equipment, and systems incorporated or to be incorporated in such construction. In exception, excludes work to produce SD-01 submittals.

1.3 SUBMITTALS

Submittals are to be identified for Contractor Quality Control approval or for information only. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals Submittal Register

1.4 SUBMITTAL CLASSIFICATION

1.4.1 Government Approved (G)

Government approval is required for any variations from the Solicitation or the Accepted Proposal and for other items as designated by the Government.

Within the terms of the Contract Clause SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION, submittals are considered to be "shop drawings."

1.4.2 Design-Build Submittal Classifications

1.4.2.1.1 Variations from the Accepted Design

Designer of Record (DOR) approval is required for any proposed variation from the accepted design that still complies with the contract before the Subcontractor is authorized to proceed with material acquisition or installation. If necessary to facilitate the project schedule, before official submission to the Contractor/Buyer, the Subcontractor and the DOR may discuss with the Contractor/Buyer a submittal proposing a variation. However, the Contractor/Buyer reserves the right to review the submittal before providing an opinion. In any case, the Contractor/Buyer will not formally agree to or provide a preliminary opinion on any variation without the DOR's approval or recommended approval. The Contractor/Buyer reserves the right to reject any design, variation that may affect furniture, furnishings, equipment selections, or operational decisions that were made, based on the reviewed and concurred design.

1.4.2.1.2 Substitutions

Unless prohibited or otherwise provided for elsewhere in the contract, where the Accepted Proposal named products, systems, materials or equipment by manufacturer, brand name, model number, or other specific identification, and the Subcontractor desires to substitute a manufacturer or model after award, submit a requested substitution for Contractor/Buyer concurrence. Include substantiation, through identifying information and the DOR's approval, that the substitute meets the contract requirements and that it is equal in function, performance, quality, and salient features to that in the accepted contract proposal. If the contract otherwise prohibits substitutions of equal named products, systems, materials or equipment by manufacturer, brand name, model number or other specific identification, the request is considered a "variation" to the contract.

1.4.3 For Information Only

For Design-build construction all submittals not requiring DOR or Government approval will be for information only. Within the terms of the Contract Clause SPECIFICATIONS AND DRAWINGS FOR CONSTRUCTION, they are not considered to be "shop drawings."

1.4.4 O&M Data

Submit data specified for a given item within 30 calendar days after the item is delivered to the contract site.

1.6 PREPARATION

1.6.1 Transmittal Form

Use the ENG Form 4025-R transmittal form for submitting both Contractor/Buyer-approved and information-only submittals. Submit in accordance with the instructions on the reverse side of the form. Properly complete this form by filling out all the heading blank spaces and identifying each item submitted. Exercise special care to ensure proper listing of the specification paragraph and sheet number of the contract drawings pertinent to the data submitted for each item.

1.6.2 Identifying Submittals

Identify submittals, except sample installations and sample panels, with the following information permanently adhered to or noted on each separate component of each submittal and noted on transmittal form. Mark each copy of each submittal identically, with the following:

a. Project title and location

b. Construction contract number

c. Dates of the drawings and revisions

d. Name, address, and telephone number of Subcontractor, supplier, manufacturer, and any other Subcontractor associated with the submittal.

e. Section number of the specification by which submittal is required

f. Submittal description (SD) number of each component of submittal

g. For a resubmission, add alphabetic suffix on submittal description, for example, submittal 18 would become 18A, to indicate resubmission

h. Product identification and location in project.

1.6.3 Submittal Format

1.6.3.1 Format of SD-01 Preconstruction Submittals

When the submittal includes a document that is to be used in the project, or is to become part of the project record, other than as a submittal, do not apply the Subcontractor’s approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.6.3.2 Format for SD-02 Shop Drawings

Provide shop drawings not less than 8 1/2 by 11 inches nor more than 30 by 42 inches, except for full-size patterns or templates. Prepare drawings to accurate size, with scale indicated, unless another form is required. Ensure drawings are suitable for reproduction and of a quality to produce clear, distinct lines and letters, with dark lines on a white background.

a. Include the nameplate data, size, and capacity on drawings. Also include applicable federal, military, industry, and technical society publication references.

b. Dimension drawings, except diagrams and schematic drawings. Prepare drawings demonstrating interface with other trades to scale. Use the same unit of measure for shop drawings as indicated on the contract drawings. Identify materials and products for work shown.

Present shop drawings sized 8 1/2 by 11 inches as part of the bound volume for submittals. Present larger drawings in sets. Submit an electronic copy of drawings in PDF format and native electronic format.

1.6.3.2.1 Drawing Identification

Include on each drawing the drawing title, number, date, and revision numbers and dates, in addition to information required in paragraph IDENTIFYING SUBMITTALS.

Number drawings in a logical sequence. Each drawing is to bear the number of the submittal in a uniform location next to the title block. Place the Contractor/Buyer contract number in the margin, immediately below the title block, for each drawing.

Reserve a blank space, no smaller than 3 inches on the right-hand side of each sheet for the Contractor/Buyer disposition stamp.

1.6.3.3 Format of SD-03 Product Data

Present product data submittals for each section as a complete, bound volume. Include a table of contents, listing the page and catalog item numbers for product data.

Indicate, by prominent notation, each product that is being submitted; indicate the specification section number and paragraph number to which it pertains.

1.6.3.3.1 Product Information

Supplement product data with material prepared for the project to satisfy the submittal requirements where product data does not exist. Identify this material as developed specifically for the project, with information and format as required for submission of SD-07 Certificates.

Provide product data in units used in the Contract documents. Where product data are included in preprinted catalogs with another unit, submit the dimensions in contract document units, on a separate sheet.

1.6.3.3.2 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or Association of Edison Illuminating Companies (AEIC), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contractor/Buyer.
State on the certificate that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.6.3.3.3 Data Submission

Collect required data submittals for each specific material, product, unit of work, or system into a single submittal that is marked for choices, options, and portions applicable to the submittal. Mark each copy of the product data identically. Partial submittals may be accepted for expedition of the construction effort.

Submit the manufacturer's instructions before installation.

1.6.3.4 Format of SD-04 Samples

1.6.3.4.1 Sample Characteristics

Furnish samples in the following sizes, unless otherwise specified or unless the manufacturer has prepackaged samples of approximately the same size as specified:

a. Sample of Equipment or Device: Full size.

b. Sample of Materials Less Than 2 by 3 inches: Built up to 8 1/2 by 11 inches.

c. Sample of Materials Exceeding 8 1/2 by 11 inches: Cut down to 8 1/2 by 11 inches and adequate to indicate color, texture, and material variations.

d. Sample of Linear Devices or Materials: 10-inch length or length to be supplied, if less than 10 inches. Examples of linear devices or materials are conduit and handrails.

1.6.3.4.2 Sample Incorporation

Reusable Samples: Incorporate returned samples into work only if so specified or indicated. Incorporated samples are to be in undamaged condition at the time of use.

Recording of Sample Installation: Note and preserve the notation of any area constituting a sample installation, but remove the notation at the final clean-up of the project.

1.6.3.5 Format of SD-05 Design Data

Provide design data and certificates on 8 1/2 by 11 inch paper. Provide a bound volume for submittals containing numerous pages.

1.6.3.6 Format of SD-06 Test Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.6.3.7 Format of SD-07 Certificates

Provide design data and certificates on 8 1/2 by 11 inch paper. Provide a bound volume for submittals containing numerous pages.

1.6.3.8 Format of SD-08 Manufacturer's Instructions

Present manufacturer's instructions submittals for each section as a complete, bound volume. Include the manufacturer's name, trade name, place of manufacture, and catalog model or number on product data. Also include applicable federal, military, industry, and technical-society publication references. If supplemental information is needed to clarify the manufacturer's data, submit it as specified for SD-07 Certificates.

Submit the manufacturer's instructions before installation.

1.6.3.8.1 Standards

Where equipment or materials are specified to conform to industry or technical-society reference standards of such organizations as the American National Standards Institute (ANSI), ASTM International (ASTM), National Electrical Manufacturer's Association (NEMA), Underwriters Laboratories (UL), or Association of Edison Illuminating Companies (AEIC),

submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Contractor/Buyer.
State on the certificate that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard.

1.6.3.9 Format of SD-09 Manufacturer's Field Reports

Provide reports on 8 1/2 by 11 inch paper in a complete bound volume.

By prominent notation, indicate each report in the submittal. Indicate the specification number and paragraph number to which each report pertains.

1.6.3.10 Format of SD-11 Closeout Submittals

When the submittal includes a document that is to be used in the project or is to become part of the project record, other than as a submittal, do not apply the Subcontractor's approval stamp to the document itself, but to a separate sheet accompanying the document.

Provide data in the unit of measure used in the contract documents.

1.6.4 Source Drawings for Shop Drawings

1.6.4.1 Source Drawings

The entire set of source drawing files (DWG) will not be provided to the Subcontractor. Request the specific Drawing Number for the preparation of shop drawings. Only those drawings requested to prepare shop drawings will be provided. These drawings are provided only after award.

1.6.4.2 Terms and Conditions

Data contained on these electronic files must not be used for any purpose other than as a convenience in the preparation of construction data for the referenced project. Any other use or reuse is at the sole risk of the Subcontractor and without liability or legal exposure to the Contractor/Buyer. The Subcontractor must make no claim, and waives to the fullest extent permitted by law any claim or cause of action of any nature against the Contractor/Buyer, its agents, or its subconsultants that may arise out of or in connection with the use of these electronic files. The Subcontractor must, to the fullest extent permitted by law, indemnify and hold the Contractor/Buyer harmless against all damages, liabilities, or costs, including reasonable attorney's fees and defense costs, arising out of or resulting from the use of these electronic files.

These electronic source drawing files are not construction documents. Differences may exist between the source drawing files and the corresponding construction documents. The Contractor/Buyer makes no representation regarding the accuracy or completeness of the electronic source drawing files, nor does it make representation to the compatibility of these files with the Subcontractor hardware or software. The Subcontractor is responsible for determining if any conflict exists. In the event that a conflict arises between the signed and sealed construction documents prepared by the Contractor/Buyer and the furnished source drawing files, the signed and sealed construction documents govern.

Use of these source drawing files does not relieve the Subcontractor of the duty to fully comply with the contract documents, including and without limitation the need to check, confirm and coordinate the work of all contractors for the project. If the Subcontractor uses, duplicates or modifies these electronic source drawing files for use in producing construction data related to this contract, remove all previous indication of ownership (seals, logos, signatures, initials and dates).

1.6.5 Electronic File Format

Provide submittals in electronic format, with the exception of material samples required for SD-04 Samples items. Compile the submittal file as a single, complete document, to include the Transmittal Form described within, and also separately attach the native files which were used to create PDF. The attached files should include the original digital files used to create the submittal. Name the electronic submittal file specifically according to its contents, and coordinate the file naming convention with the Contractor/Buyer. Electronic files must be of sufficient quality that all information is legible. Use PDF as the electronic format, unless otherwise specified or directed by the Contractor/Buyer. Generate PDF files from original documents with bookmarks so that the text included in the PDF file is searchable and can be copied. If documents are scanned, optical character resolution (OCR) routines are required. Index and bookmark files exceeding 30 pages to allow efficient navigation of the file. When required, the electronic file must include a valid electronic signature or a scan of a signature.

E-mail electronic submittal documents smaller than 10MB to an e-mail address as directed by the Contractor/Buyer. Provide electronic documents over 10 MB on an optical disc or through an electronic file sharing system.

1.7 QUANTITY OF SUBMITTALS

1.7.1 Number of SD-01 Preconstruction Submittal Copies

Unless otherwise specified, submit two sets of administrative submittals.

1.7.2 Number of SD-02 Shop Drawing Copies

Submit two copies of submittals of shop drawings requiring review and approval by a QC organization. Submit two copies of shop drawings requiring review and approval by the Contractor/Buyer.

1.7.3 Number of SD-03 Product Data Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.4 Number of SD-04 Samples

Submit two samples, or two sets of samples showing the range of variation, of each required item. One approved sample or set of samples will be retained by the approving authority and one will be returned to the Subcontractor/Supplier.

1.7.5 Number of SD-05 Design Data Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.6 Number of SD-06 Test Report Copies

Submit in compliance with quantity and quality requirements specified for shop drawings, other than field test results that will be submitted with QC reports.

1.7.7 Number of SD-07 Certificate Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.8 Number of SD-08 Manufacturer's Instructions Copies

Submit in compliance with quantity requirements specified for shop drawings.

1.7.9 Number of SD-09 Manufacturer's Field Report Copies

Submit in compliance with quantity and quality requirements specified for shop drawings other than field test results that will be submitted with QC reports.

1.7.10 Number of SD-10 Operation and Maintenance Data Copies

Submit two copies of O&M data to the Contractor/Buyer for review and approval.

1.7.11 Number of SD-11 Closeout Submittals Copies

Unless otherwise specified, submit two sets of administrative submittals.

1.8 INFORMATION ONLY SUBMITTALS

Provide information-only submittals to the Contractor/Buyer a minimum of 14 calendar days prior to the Preparatory Meeting for the associated Definable Feature of Work (DFOW). Normally, submittals for information only will not be returned. However, the Contractor/Buyer reserves the right to return unsatisfactory submittals and require the Subcontractor to resubmit any item found not to comply with the contract. This does not relieve the Subcontractor from the obligation to furnish material conforming to the plans and specifications; will not prevent the Contractor/Buyer from requiring removal and replacement of nonconforming material incorporated in the work; and does not relieve the Subcontractor/Supplier of the requirement to furnish samples for testing by the Contractor/Buyer laboratory or for check testing by the Contractor/Buyer in those instances where the technical specifications so prescribe.

1.8.1 Submittal Management

Prepare and maintain a submittal register, as the work progresses.

Thereafter, the Subcontractor is to track all submittals by maintaining a complete list, including completion of all data columns and all dates on which submittals are received by and returned by the Contractor/Buyer.

1.8.2 Subcontractor Use of Submittal Register

Update with each submittal throughout the contract.

1.8.3 Delivery of Copies

Submit an updated electronic copy of the submittal register to the Contractor/Buyer with each invoice request, unless a paper copy is requested by the Contractor/Buyer.

1.9 VARIATIONS

Variations from contract requirements require Contractor/Buyer approval pursuant to contract Clause FAR 52.236-21 Specifications and Drawings for Construction, and will be considered where advantageous to the Contractor/Buyer.

1.9.1 Considering Variations

Discussion of variations with the Contractor/Buyer before submission of a variation submittal will help ensure that functional and quality requirements are met and minimize rejections and resubmittals. For variations that include design changes or some material or product substitutions, the Contractor/Buyer may require an evaluation and analysis by a licensed professional engineer hired by the Subcontractor.

Specifically point out variations from contract requirements in a variation submittal. Failure to point out variations may cause the Contractor/Buyer to require rejection and removal of such work at no additional cost to the Contractor/Buyer.

1.9.2 Proposing Variations

The Contractor/Buyer will indicate an approval or disapproval of the variation request; and if not approved as submitted, will indicate the Contractor/Buyer's reasons therefore. Any work done before such approval is received is performed at the Subcontractor's risk.

Specifically point out variations from contract requirements in a variation submittal. Failure to point out variations may cause the Contractor/Buyer to require rejection and removal of such work at no additional cost to the Contractor/Buyer.

Check the column "variation" of ENG Form 4025 for submittals that include variations proposed by the Subcontractor. Set forth in writing the reason for any variations and note such variations on the submittal. The Contractor/Buyer reserves the right to rescind inadvertent approval of submittals containing unnoted variations.

1.9.3 Warranting that Variations are Compatible

When delivering a variation for approval, the Subcontractor warrants that this contract has been reviewed to establish that the variation, if incorporated, will be compatible with other elements of work.

1.9.4 Review Schedule Extension

In addition to the normal submittal review period, a period of 14 calendar days will be allowed for the Contractor/Buyer to consider submittals with variations.

1.10 SCHEDULING

Schedule and submit concurrently product data and shop drawings covering component items forming a system or items that are interrelated. Submit pertinent certifications at the same time. No delay damages or time extensions will be allowed for time lost in late submittals.

a. Coordinate scheduling, sequencing, preparing, and processing of submittals with performance of work so that work will not be delayed by submittal processing. The Subcontractor is responsible for additional time required for Contractor/Buyer reviews resulting from required resubmittals. The review period for each resubmittal is the same as for the initial submittal.

b. Submittals required by the contract documents are listed on the submittal register. If a submittal is listed in the submittal register but does not pertain to the contract work, the Subcontractor is to include the submittal in the register and annotate it "N/A" with a brief explanation. Approval by the Contractor/Buyer does not relieve the Subcontractor of supplying submittals required by the contract documents but that have been omitted from the register or marked "N/A."

c. Resubmit the submittal register and annotate it monthly with actual submission and approval dates. When all items on the register have been fully approved, no further resubmittal is required.

d. Except as specified otherwise, allow a review period, beginning with receipt by the approving authority, that includes at least 20 working days for submittals where the Contractor/Buyer is the approving authority. The period of review for submittals with Contractor/Buyer approval begins when the Contractor/Buyer receives the submittal from the QC organization.

1.10.1 Reviewing, Certifying, and Approving Authority

The QC Manager is responsible for reviewing all submittals and certifying that they are in compliance with contract requirements. The approving authority on submittals is the QC Manager unless otherwise specified.

1.10.2 Constraints

Conform to provisions of this section, unless explicitly stated otherwise for submittals listed or specified in this contract.

Submit complete submittals for each definable feature of the work. At the same time, submit components of definable features that are interrelated as a system.

When acceptability of a submittal is dependent on conditions, items, or materials included in separate subsequent submittals, the submittal will be returned without review.

Approval of a separate material, product, or component does not imply approval of the assembly in which the item functions.

1.10.3 QC Organization Responsibilities

a. Review submittals for conformance with project design concepts and compliance with contract documents.

b. Process submittals based on the approving authority indicated in the submittal register.

(1) When the QC manager is the approving authority, take appropriate action on the submittal from the possible actions defined in paragraph APPROVED SUBMITTALS.

(2) When the Contractor/Buyer is the approving authority or when variation has been proposed, forward the submittal to the Contractor/Buyer, along with a certifying statement, or return the submittal marked "not reviewed" or "revise and resubmit" as appropriate. The QC organization's review of the submittal determines the appropriate action.

c. Ensure that material is clearly legible.

d. Stamp each sheet of each submittal with a QC certifying statement or an approving statement, except that data submitted in a bound volume or on one sheet printed on two sides may be stamped on the front of the first sheet only.

(1) When the approving authority is the Contractor/Buyer, the QC organization will certify submittals forwarded to the Contractor/Buyer with the following certifying statement:

"I hereby certify that the (equipment) (material) (article) shown and marked in this submittal is that proposed to be incorporated with Contract Number [______] is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is submitted for Contractor/Buyer approval.

Certified by Submittal Reviewer ________________________, Date _________
(Signature when applicable)

Certified by QC Manager __________________________________, Date _______"
(Signature)

(2) When approving authority is the QC manager, the QC manager will use the following approval statement when returning submittals to the Subcontractor as "Approved" or "Approved as Noted."

"I hereby certify that the (material) (equipment) (article) shown and marked in this submittal and proposed to be incorporated with Contract Number [______] is in compliance with the contract drawings and specification, can be installed in the allocated spaces, and is approved for use.

Certified by Submittal Reviewer _________________________, Date _______
(Signature when applicable)

Approved by QC Manager ____________________________________, Date ______"

(Signature)

e. Sign the certifying statement or approval statement. The QC organization member designated in the approved QC plan is the person signing certifying statements. The use of original ink for signatures is required. Stamped signatures are not acceptable.

f. Update the submittal register as submittal actions occur, and maintain the submittal register at the project site until final acceptance of all work by the Contractor/Buyer.

g. Retain a copy of approved submittals and approved samples at the project site.

1.11 APPROVING AUTHORITY

When the approving authority is the Contractor/Buyer, the Contractor/Buyer will:

a. Note the date on which the submittal was received from the Subcontractor/Supplier.

b. Review submittals for approval within the scheduling period specified and only for conformance with project design concepts and compliance with contract documents.

c. Identify returned submittals with one of the actions defined in paragraph REVIEW NOTATIONS and with comments and markings appropriate for the action indicated.

Upon completion of review of submittals requiring Contractor/Buyer approval, stamp and date submittals. One copy of the submittal will be retained by the Contractor/Buyer and one copy of the submittal will be returned to the Subcontractor. If the Contractor/Buyer performs a conformance review of other Designer of Record approved submittals, the submittals will be identified and returned, as described above.

1.11.1 Review Notations

Submittals will be returned to the Subcontractor with the following notations:

Submittals marked "approved" or "accepted" authorize proceeding with the work covered.

a. Submittals marked "approved as noted" or "approved, except as noted, resubmittal not required," authorize proceeding with the work covered provided that the Subcontractor takes no exception to the corrections.

b. Submittals marked "not approved," "disapproved," or "revise and resubmit" indicate incomplete submittal or noncompliance with the contract requirements or design concept. Resubmit with appropriate changes. Do not proceed with work for this item until the resubmittal is approved.

c. Submittals marked "not reviewed" indicate that the submittal has been previously reviewed and approved, is not required, does not have evidence of being reviewed and approved by Subcontractor, or is not complete. A submittal marked "not reviewed" will be returned with an explanation of the reason it is not reviewed. Resubmit submittals returned for lack of review by Subcontractor or for being incomplete, with appropriate action, coordination, or change.

d. Submittals marked "receipt acknowledged" indicate that submittals have been received by the Contractor/Buyer. This applies only to "information-only submittals" as previously defined.

1.12 DISAPPROVED SUBMITTALS

Make corrections required by the Contractor/Buyer. If the Subcontractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications, give notice to the Contractor/Buyer as required under the FAR clause titled CHANGES. The Subcontractor is responsible for the dimensions and design of connection details and the construction of work. Failure to point out variations may cause the Contractor/Buyer to require rejection and removal of such work at the Subcontractor's expense.

If changes are necessary to submittals, make such revisions and resubmit in accordance with the procedures above. No item of work requiring a submittal change is to be accomplished until the changed submittals are approved.

1.13 APPROVED SUBMITTALS

The Contractor/Buyer's approval of submittals is not to be construed as a complete check, and indicates only that the general method of construction, materials, detailing, and other information are satisfactory. The design, general method of construction, materials, detailing, and other information appear to meet the Solicitation and Accepted Proposal.

Approval or acceptance by the Contractor/Buyer for a submittal does not relieve the Subcontractor of the responsibility for meeting the contract requirements or for any error that may exist, because under the Quality Control (QC) requirements of this contract, the Subcontractor is responsible for ensuring information contained within each submittal accurately conforms with the requirements of the contract documents.

After submittals have been approved or accepted by the Contractor/Buyer, no resubmittal for the purpose of substituting materials or equipment will be considered unless accompanied by an explanation of why a substitution is necessary.

1.14 APPROVED SAMPLES

Approval of a sample is only for the characteristics or use named in such approval and is not to be construed to change or modify any contract requirements. Before submitting samples, provide assurance that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been approved.

Match the approved samples for materials and equipment incorporated in the work. If requested, approved samples, including those that may be damaged in testing, will be returned to the Subcontractor, at its expense, upon completion of the contract. Unapproved samples will also be returned to the Subcontractor at its expense, if so requested.

Failure of any materials to pass the specified tests will be sufficient cause for refusal to consider, under this contract, any further samples of the same brand or make as that material. The Contractor/Buyer reserves the right to disapprove any material or equipment that has previously proved unsatisfactory in service.

Samples of various materials or equipment delivered on the site or in place may be taken by the Contractor/Buyer for testing. Samples failing to meet contract requirements will automatically void previous approvals. Replace such materials or equipment to meet contract requirements.

1.15 WITHHOLDING OF PAYMENT

Payment for materials incorporated in the work will not be made if required approvals have not been obtained. No payment for materials incorporated in the work will be made unless all required DOR approvals or required Contractor/Buyer approvals have been obtained. No payment will be made for any materials incorporated into the work for any conformance review submittals or information-only submittals found to contain errors or deviations from the Solicitation or Accepted Proposal.

1.16 CERTIFICATION OF SUBMITTAL DATA

Certify the submittal data as follows on Form ENG 4025: "I certify that the above submitted items had been reviewed in detail and are correct and in strict conformance with the contract drawings and specifications except as otherwise stated.

______NAME OF SUBCONTRACTOR ____SIGNATURE OF SUBCONTRACTOR

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

-- End of Section --

SECTION 01 42 00: SOURCES FOR REFERENCE PUBLICATIONS

02/19, CHG 1: 08/23

PART 1 GENERAL

1.1 REFERENCES

Various publications are referenced in other sections of the specifications to establish requirements for the work. These references are identified in each section by document number, date and title. The document number used in the citation is the number assigned by the standards producing organization (e.g., ASTM B564 Standard Specification for Nickel Alloy Forgings). However, when the standards producing organization has not assigned a number to a document, an identifying number has been assigned for reference purposes.

1.2 ORDERING INFORMATION

The addresses of the standards publishing organizations whose documents are referenced in other sections of these specifications are listed below, and if the source of the publications is different from the address of the sponsoring organization, that information is also provided.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)
444 North Capital Street, NW, Suite 249 Washington, DC 20001
Ph: 202-624-5800
Fax: 202-624-5806
E-Mail: info@aashto.org
Internet: https://www.transportation.org/

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)
330 N. Wabash Ave., Suite 2000
Chicago, IL 60611
Ph: 202-367-1155
E-mail: info@americanbearings.org
Internet: https://www.americanbearings.org/

AMERICAN CONCRETE INSTITUTE (ACI)
38800 Country Club Drive Farmington Hills, MI 48331-3439 Ph: 248-848-3700
Fax: 248-848-3701
Internet: https://www.concrete.org/

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
1899 L Street, NW,11th Floor Washington, DC 20036
Ph: 202-293-8020
Fax: 202-293-9287
E-mail: storemanager@ansi.org Internet: https://www.ansi.org/

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)
1801 Alexander Bell Drive

Reston, VA 20191
Ph: 800-548-2723; 703-295-6300
Internet: https://www.asce.org/

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
Two Park Avenue

New York, NY 10016-5990 Ph: 800-843-2763
Fax: 973-882-1717
E-mail: customercare@asme.org Internet: https://www.asme.org/

AMERICAN WATER WORKS ASSOCIATION (AWWA)
6666 W. Quincy Avenue Denver, CO 80235 USA
Ph: 303-794-7711 or 800-926-7337
Fax: 303-347-0804
Internet: https://www.awwa.org/

AMERICAN WELDING SOCIETY (AWS) 8669 NW 36 Street, #130
Miami, FL 33166-6672
Ph: 800-443-9353
Internet: https://www.aws.org/

ASTM INTERNATIONAL (ASTM)
100 Barr Harbor Drive, P.O. Box C700 West Conshohocken, PA 19428-2959 Ph: 610-832-9500
Fax: 610-832-9555
E-mail: service@astm.org Internet: https://www.astm.org/

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)
310 Maxwell Road, Suite 200
Alpharetta, GA 30009
Ph: 678-393-9990
Fax: 678-393-9998
E-mail: emikoski@ecianow.org Internet: https://www.ecianow.org

ELECTRONIC INDUSTRIES ALLIANCE (EIA)
EIA has become part of the ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)
CEN-CENELEC Management Centre Rue de la Science 23
B - 1040 Brussels, Belgium Ph: 32-2-550-08-11
Fax: 32-2-550-08-19
Internet: https://www.cen.eu/

FORESTRY SUPPLIERS INC. (FSUP)
205 West Rankin Street
P.O. Box 8397
Jackson, MS 39284-8397
Ph: 800-752-8460
Internet: https://www/forestry-suppliers.com

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)
P.O. Box 9140
Boulder, CO 80301-9140
Ph: 303-357-1000
Fax: 303-357-1070
E-mail: gsaservice@geosociety.org Internet: http://www.geosociety.org

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
445 and 501 Hoes Lane
Piscataway, NJ 08854-4141
Ph: 732-981-0060 or 800-701-4333

Fax: 732-981-9667
E-mail: onlinesupport@ieee.org Internet: https://www.ieee.org/

INTERNATIONAL CODE COUNCIL (ICC)
500 New Jersey Avenue, NW
6th Floor, Washington, DC 20001 Ph: 800-786-4452 or 888-422-7233
Fax: 202-783-2348
E-mail: order@iccsafe.org Internet: https://www.iccsafe.org/

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)
3050 Old Centre Ave. Suite 101
Portage, MI 49024
Ph: 269-488-6382
Fax: 269-488-6383
Internet: https://www.netaworld.org/

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
3, rue de Varembe, 1st floor
P.O. Box 131
CH-1211 Geneva 20, Switzerland Ph: 41-22-919-02-11
Fax: 41-22-919-03-00
E-mail: info@iec.ch
Internet: https://www.iec.ch/

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
ISO Central Secretariat BIBC II
Chemin de Blandonnet 8
CP 401 - 1214 Vernier, Geneva Switzerland
Ph: 41-22-749-01-11
E-mail: central@iso.ch Internet: https://www.iso.org

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)
67 T.W. Alexander Drive PO Box 12277
Research Triangle Park, NC 27709 Ph: 919-549-8411
Fax: 919-549-8288
E-mail: info@isa.org
Internet: https://www.isa.org/

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
1300 North 17th Street, Suite 900
Arlington, VA 22209
Ph: 703-841-3200
Internet: https://www.nema.org

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1 Batterymarch Park
Quincy, MA 02169-7471
Ph: 800-344-3555
Fax: 800-593-6372
Internet: https://www.nfpa.org

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)
100 Bureau Drive
Gaithersburg, MD 20899
Ph: 301-975-2000
Internet: https://www.nist.gov/

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)
1320 North Courthouse Rosd, Suite 200
Arlington, VA 22201
Ph: 703-907-7700
Fax: 703-907-7727
E-mail: marketing@tiaonline.org Internet:
https://www.tiaonline.org/

U.S. ARMY CORPS OF ENGINEERS (USACE)
CRD-C DOCUMENTS available on Internet:
http://www.wbdg.org/ffc/army-coe/standards Order Other Documents from:
Official Publications of the Headquarters, USACE E-mail:
hqpublications@usace.army.mil
Internet: http://www.publications.usace.army.mil/ or
https://www.hnc.usace.army.mil/Missions/Engineering-Directorate/TECHINFO/

U.S. DEPARTMENT OF DEFENSE (DOD)
Order DOD Documents from:
Room 3A750-The Pentagon 1400 Defense Pentagon
Washington, DC 20301-1400
Ph: 703-571-3343
Fax: 215-697-1462
E-mail: customerservice@ntis.gov Internet: https://www.ntis.gov/
Obtain Military Specifications, Standards and Related Publications from:
Acquisition Streamlining and Standardization Information System (ASSIST)
Department of Defense Single Stock Point (DODSSP) Document Automation and Production Service (DAPS) Building 4/D
700 Robbins Avenue
Philadelphia, PA 19111-5094
Ph: 215-697-6396 - for account/password issues
Internet: https://assist.dla.mil/online/start/; account registration required
Obtain Unified Facilities Criteria (UFC) from: Whole Building Design Guide (WBDG)
National Institute of Building Sciences (NIBS) 1090 Vermont Avenue NW, Suite 700
Washington, DC 20005
Ph: 202-289-7800
Fax: 202-289-1092
Internet:
https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)
1200 Pennsylvania Avenue, N.W. Washington, DC 20004
Ph: 202-564-4700
Internet: https://www.epa.gov
--- Some EPA documents are available only from: National Technical Information Service (NTIS) 5301 Shawnee Road
Alexandria, VA 22312
Ph: 703-605-6060 or 1-800-363-2068
Fax: 703-605-6880
TDD: 703-487-4639
E-mail: info@ntis.gov
Internet: https://www.ntis.gov/

U.S. GENERAL SERVICES ADMINISTRATION (GSA)
General Services Administration 1800 F Street, NW
Washington, DC 20405
Ph: 1-844-472-4111
Internet: https://www.gsaelibrary.gsa.gov/ElibMain/home.do Obtain documents from:
Acquisition Streamlining and Standardization Information System (ASSIST)
Internet: https://assist.dla.mil/online/start/; account registration required

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)
8601 Adelphi Road
College Park, MD 20740-6001 Ph: 866-272-6272
Internet: https://www.archives.gov/ Order documents from:
Superintendent of Documents
U.S. Government Publishing Office (GPO) 732 N. Capitol Street, NW
Washington, DC 20401
Ph: 202-512-1800 or 866-512-1800
Bookstore: 202-512-0132 Internet: https://www.gpo.gov/

UNDERWRITERS LABORATORIES (UL)
2600 N.W. Lake Road Camas, WA 98607-8542
Ph: 877-854-3577 or 360-817-5500
E-mail: CustomerExperienceCenter@ul.com Internet: https://www.ul.com/
UL Directories available through IHS at https://ihsmarkit.com/

PART 2 PRODUCTS

Not used

PART 3 EXECUTION

Not used

-- End of Section --

SECTION 03 30 53: MISCELLANEOUS CAST-IN-PLACE CONCRETE
05/14

PART 1 GENERAL

1.1 SUMMARY

Perform all work in accordance with ACI 318.

1.2 UNIT PRICES

1.2.1 Concrete Payment

Payment will cover all costs associated with manufacturing, furnishing, delivering, placing, finishing, and curing of concrete for the various items of the schedule, including the cost of all formwork. Payment for concrete work, for which payment is made as a lump sum, including but not limited to grout, preformed expansion joints, field-molded sealants, waterstops, reinforcing steel bars or wire reinforcement, is to be included in this unit price payment item.

1.2.2 Measurement

Concrete will be measured for payment on the basis of the actual volume of concrete within the pay lines and design dimensions of the structures as indicated. Measurement of concrete placed against the sides of any excavation without the use of intervening forms will be made only within the pay lines of the structure. No deductions will be made for rounded or beveled edge, for space occupied by metal work, for electrical conduits or timber, or for voids or embedded items that are either less than 5 cubic feet in volume or 1 square foot in cross section.

1.2.3 Unit of Measure

Unit of measure: cubic yard.

1.3 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 301	(2016) Specifications for Structural Concrete
ACI 302.1R	(2015) Guide for Concrete Floor and Slab Construction
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing Transporting, and Placing Concrete
ACI 305R	(2020) Guide to Hot Weather Concreting
ACI 306R	(2016) Guide to Cold Weather Concreting

ACI 318	(2014; Errata 1-2 2014; Errata 3-5 2015; Errata 6 2016; Errata 7-9 2017) Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14)
ACI 347R	(2014; Errata 1 2017) Guide to Formwork for Concrete
ACI SP-66	(2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM A615/A615M	(2022) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A1064/A1064M	(2022) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31/C31M	(2022) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2021) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94/C94M	(2022a) Standard Specification for Ready-Mixed Concrete
ASTM C143/C143M	(2020) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C172/C172M	(2017) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173/C173M	(2016) Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C231/C231M	(2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2019) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494/C494M	(2019; E 2022) Standard Specification for Chemical Admixtures for Concrete
ASTM C595/C595M	(2021) Standard Specification for Blended Hydraulic Cements
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C685/C685M	(2017) Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing

ASTM C920	(2018) Standard Specification for Elastomeric Joint Sealants
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1064/C1064M	(2017) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C1157/C1157M	(2020a) Standard Performance Specification for Hydraulic Cement
ASTM C1260	(2021) Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	(2022) Standard Test Method for Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602/C1602M	(2022) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM D75/D75M	(2019) Standard Practice for Sampling Aggregates
ASTM D98	(2015) Calcium Chloride
ASTM D412	(2016; R 2021) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D1752	(2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM E96/E96M	(2022a; E 2023) Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
ASTM E1155	(2020) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers
ASTM E1155M	(2014) Standard Test Method for Determining Floor Flatness and Floor Levelness Numbers (Metric)
ASTM E1643	(2018a) Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs
ASTM E1745	(2017; R 2023) Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
ASTM E1993/E1993M	(1998; R 2020) Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 513	(1974) Corps of Engineers Specifications for Rubber Waterstops
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 247	Comprehensive Procurement Guideline for Products Containing Recovered Materials

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings;

SD-03 Product Data

Air-Entraining Admixture Accelerating Admixture
Water-Reducing or Retarding Admixture Curing Materials
Expansion Joint Filler Strips, Premolded Joint Sealants - Field Molded Sealants Waterstops
Mix Design Data; Ready-Mix Concrete
Curing Compound
Mechanical Reinforcing Bar Connectors

SD-06 Test Reports

Aggregates
Concrete Mixture Proportions; Compressive Strength Testing; Slump; Air Content Water

SD-07 Certificates

Cementitious Materials Pozzolan
Fly Ash
CPG for recycled materials or appropriate Waiver Form
Aggregates
Delivery Tickets

SD-08 Manufacturer's Instructions

Curing Compound

1.5 QUALITY ASSURANCE

Indicate specific locations of [Concrete Placement] [Forms] [Steel Reinforcement] [Accessories] [Expansion Joints] [Construction Joints] [Contraction Joints] [Control Joints] on installation drawings and include, but not be limited to, square feet of concrete placements, thicknesses and widths, plan dimensions, and arrangement of cast-in-place concrete section.

1.5.1 Regulatory Requirements

The state statutory and regulatory requirements: [CA] form a part of this specification to the extent referenced. Submit CPG for recycled materials or appropriate Waiver Form.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The Contractor/Buyer retains the option to sample and test aggregates and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary to assist the Contractor/Buyer in procurement of representative test samples. Obtain samples of aggregates at the point of batching in accordance with ASTM D75/D75M. Sample concrete in accordance with ASTM C172/C172M. Determine slump and air content in accordance with ASTM C143/C143M and ASTM C231/C231M, respectively, when cylinders are molded. Prepare, cure, and transport compression test specimens in accordance with ASTM C31/C31M. Test compression test specimens in accordance with ASTM C39/C39M. Take samples for strength tests not less than once each shift in which concrete is produced. Provide a minimum of five specimens from each sample; two to be tested at 28 days (90 days if pozzolan is used) for acceptance, two will be tested at 7 days for information and one held in reserve.

2.1.1 Strength

Acceptance test results are the average strengths of two specimens tested at 28 days (90 days if pozzolan is used). The strength of the concrete is considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength, f'c, but not more than 20 percent, and no individual acceptance test result falls below f'c by more than 500 psi.

2.1.2 Construction Tolerances

Apply a Class "C" finish to all surfaces except those specified to receive a Class "D" finish. Apply a Class "D" finish to all post-construction surfaces which will be permanently concealed. Surface requirements for the classes of finish required are as specified in ACI 117.

2.1.3 Concrete Mixture Proportions

Concrete mixture proportions are the responsibility of the Subcontractor. Mixture proportions must include the dry weights of cementitious material(s); the nominal maximum size of the coarse aggregate; the specific gravities, absorptions, and saturated surface-dry weights of fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per yard of concrete. Provide materials included in the mixture proportions of the same type and from the same source as will be used on the project. The specified compressive strength f'c is 3,000 psi at 28 days (90 days if pozzolan is used). The maximum nominal size coarse aggregate is ¾-inch, in accordance with ACI 304R. The air content must be between 4.5 and 7.5 percent with a slump between 2 and 5 inches. The maximum water-cementitious material ratio is 0.50. Submit the applicable test reports and mixture proportions that will produce concrete of the quality required, ten days prior to placement of concrete.

2.2 MATERIALS

Submit manufacturer's literature from suppliers which demonstrates compliance with applicable specifications for the specified materials.

2.2.1 Cementitious Materials

Submit Manufacturer's certificates of compliance, accompanied by mill test reports, attesting that the concrete materials meet the requirements of the specifications in accordance with the Special Clause "CERTIFICATES OF COMPLIANCE". Also, certificates for all material conforming to EPA's Comprehensive Procurement Guidelines (CPG), in accordance with 40 CFR 247. Provide cementitious materials that conform to the appropriate specifications listed:

2.2.1.1 Portland Cement

ASTM C150/C150M, Type I or II with tri-calcium aluminates (C_3A) content less than 10 percent and a maximum cement-alkali content of 0.80 percent Na_2O (sodium oxide) equivalent.

2.2.1.3 Pozzolan

Provide pozzolan that conforms to ASTM C618, Class F, including requirements of Tables 1A and 2A.

2.2.2 Aggregates

For fine and coarse aggregates meet the quality and grading requirements of ASTM C33/C33M and test and evaluate for alkali-aggregate reactivity in accordance with ASTM C1260. Perform evaluation of fine and coarse aggregates separately and in combination, matching the proposed mix design proportioning. All results of the separate and combination testing must have a measured expansion less than 0.08 percent at 28 days after casting. If the test data indicates an expansion of 0.08 percent or greater, reject the aggregate(s) or perform additional testing using ASTM C1260 and ASTM C1567. Perform the additional testing using ASTM C1260 and ASTM C1567 using the low alkali Portland cement in combination with ground granulated blast furnace (GGBF) slag, or Class F fly ash. Use GGBF slag in the range of 40 to 50 percent of the total cementitious material by mass. Use Class F fly ash in the range of 25 to 40 percent of the total cementitious material by mass]. Submit certificates of compliance and test reports for aggregates showing the material(s) meets the quality and grading requirements of the specifications under which it is furnished.

2.2.3 Admixtures

Provide admixtures, when required or approved, in compliance with the appropriate specification listed. Retest chemical admixtures that have been in storage at the project site, for longer than 6 months or that have been subjected to freezing, at the expense of the Subcontractor at the request of the Contractor/Buyer and will be rejected if test results are not satisfactory.

2.2.3.1 Air-Entraining Admixture

Provide air-entraining admixture that meets the requirements of ASTM C260/C260M.

2.2.3.2 Accelerating Admixture

Provide calcium chloride meeting the requirements of ASTM D98. Other accelerators must meet the requirements of ASTM C494/C494M, Type C or E.

]2.2.3.3 Water-Reducing or Retarding Admixture

Provide water-reducing or retarding admixture meeting the requirements of ASTM C494/C494M, Type A, B, or D. [High-range water reducing admixture Type F [or G] may be used only when approved, approval being contingent upon particular placement requirements as described in the Subcontractor's Quality Control Plan.]

2.2.4 Water

Mixing and curing water in compliance with the requirements of ASTM C1602/C1602M; free of injurious amounts of oil, acid, salt, or alkali. Submit test report showing water complies with ASTM C1602/C1602M.

2.2.5 Reinforcing Steel

Provide reinforcing bars conforming to the requirements of ASTM A615/A615M, Grade 60, deformed. Provide welded steel wire reinforcement conforming to the requirements of ASTM A1064/A1064M. Detail reinforcement not indicated in accordance with ACI 301 and ACI SP-66. Provide mechanical reinforcing bar connectors in accordance with ACI 301 and provide 125 percent minimum yield strength of the reinforcement bar.

2.2.6 Expansion Joint Filler Strips, Premolded

Expansion joint filler strips, premolded of sponge rubber conforming to ASTM D1752, Type I.

2.2.7 Joint Sealants - Field Molded Sealants

Conform to ASTM C920, Type M, Grade NS, Class 25, use NT for vertical joints and Type M, Grade P, Class 25, use T for horizontal joints. Provide polyethylene tape, coated paper, metal foil, or similar type bond breaker materials. The backup material needs to be compressible, non shrink, nonreactive with the sealant, and a nonabsorptive material such as extruded butyl or polychloroprene foam rubber. Immediately prior to installation of field-molded sealants, clean the joint of all debris and further cleaned using water, chemical solvents, or other means as recommended by the sealant manufacturer or directed.

2.2.8 Formwork

Design and engineer the formwork as well as its construction in accordance with ACI 301 Section 2 and 5 and ACI 347R. Fabricate of wood, steel, or other approved material. Submit formwork design prior to the first concrete placement.

2.2.9 Form Coatings

Provide form coating in accordance with ACI 301.

2.2.11 Curing Materials

Provide curing materials in accordance with ACI 301, Section 5.

2.3 READY-MIX CONCRETE

Provide ready-mix concrete with mix design data conforming to ACI 301 Part 4. Submit delivery tickets in accordance with ASTM C94/C94M for each ready-mix concrete delivery, include the following additional information:

a. Type and brand cement

b. Cement content in 94-pound bags per cubic yard of concrete

c. Maximum size of aggregate

d. Amount and brand name of admixture

e. Total water content expressed by water cementitious material ratio

2.4 ACCESSORIES

2.4.1 Waterstops

2.4.1.1 PVC Waterstop

Polyvinylchloride waterstops conforming to COE CRD-C 572.

2.4.1.2 Rubber Waterstop

Rubber waterstops conforming to COE CRD-C 513.

2.4.1.3 Thermoplastic Elastomeric Rubber Waterstop

Thermoplastic elastomeric rubber waterstops conforming to ASTM D471.

2.4.1.4 Hydrophilic Waterstop

Swellable strip type compound of polymer modified chloroprene rubber that swells upon contact with water conforming to ASTM D412 as follows: Tensile strength 420 psi minimum; ultimate elongation 600 percent minimum. Minimum hardness of 50 on the type A durometer and the volumetric expansion ratio in distilled water at 70 degrees F; 3 to 1 minimum.

2.4.2 Curing Compound

Provide curing compound conforming to ASTM C309. Submit manufactures instructions for placing curing compound.

PART 3 EXECUTION

3.1 PREPARATION

Prepare construction joints to expose coarse aggregate. The surface must be clean, damp, and free of laitance. Construct ramps and walkways, as necessary, to allow safe and expeditious access for concrete and workers. Remove snow, ice, standing or flowing water, loose particles, debris, and foreign matter. Satisfactorily compact earth foundations. Make spare vibrators available. Placement cannot begin until the entire preparation has been accepted by the Contractor/Buyer.

3.1.1 Embedded Items

Secure reinforcement in place after joints, anchors, and other embedded items have been positioned. Arrange internal ties so that when the forms are removed the metal part of the tie is not less than 2 inches from concrete surfaces permanently exposed to view or exposed to water on the finished structures. Prepare embedded items so they are free of oil and other foreign matters such as loose coatings or rust, paint, and scale. The embedding of wood in concrete is permitted only when specifically authorized or directed. Provide all equipment needed to place, consolidate, protect, and cure the concrete at the placement site and in good operating condition.

3.1.2 Formwork Installation

Forms must be properly aligned, adequately supported, and mortar-tight. Provide smooth form surfaces, free from irregularities, dents, sags, or holes when used for permanently exposed faces. Chamfer all exposed joints and edges, unless otherwise indicated.

3.1.4 Production of Concrete

3.1.4.1 Ready-Mixed Concrete

Provide ready-mixed concrete conforming to ASTM C94/C94M except as otherwise specified.

3.1.4.2 Concrete Made by Volumetric Batching and Continuous Mixing Conform

to ASTM C685/C685M.

3.1.5 Waterstops

Install and splice waterstops as directed by the manufacturer.

3.2 CONVEYING AND PLACING CONCRETE

Convey and place concrete in accordance with ACI 301, Section 5.

3.2.1 Cold-Weather Requirements

Place concrete in cold weather in accordance with ACI 306R

3.2.2 Hot-Weather Requirements

Place concrete in hot weather in accordance with ACI 305R

3.3 FINISHING

3.3.1 Temperature Requirement

Do not finish or repair concrete when either the concrete or the ambient temperature is below 50 degrees F.

3.3.2 Finishing Formed Surfaces

Remove all fins and loose materials, and surface defects including filling of tie holes. Repair all honeycomb areas and other defects. Remove all unsound concrete from areas to be repaired. Ream or chip surface defects greater than ½-inch in diameter and holes left by removal of tie rods in all surfaces not to receive additional concrete and fill with dry-pack mortar. Brush-coat the prepared area with an approved epoxy resin or latex bonding compound or with a neat cement grout after dampening and filling with mortar or concrete. Use a blend of Portland cement and white cement in mortar or concrete for repairs to all surfaces permanently exposed to view so that the final color when cured is the same as adjacent concrete.

3.4 CURING AND PROTECTION

Cure and protect in accordance with ACI 301, Section 5.

3.5 FORM WORK

Provide form work in accordance with ACI 301, Section 2 and Section 5.

3.5.1 Removal of Forms

Remove forms in accordance with ACI 301, Section 2.

a. Provide form release agent that is colorless, biodegradable, and water-based, with a zero VOC content.
b. Provide product that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
c. Provide form release agent that reduces formwork moisture absorption, and does not contain diesel fuel, petroleum-based lubricating oils, waxes, or kerosene. Submit documentation indicating type of biobased material in product and biobased content. Indicate relative dollar value of biobased content products to total dollar value of products included in project.
d. Submit manufacturer's product data on formwork release agent for use on each form-facing material.

3.6 STEEL REINFORCING

Reinforcement must be free from loose, flaky rust and scale, and free from oil, grease, or other coating which might destroy or reduce the reinforcement's bond with the concrete.

3.6.1 Fabrication

Shop fabricate steel reinforcement in accordance with ACI 318 and ACI SP-66. Provide shop details and bending in accordance with ACI 318 and ACI SP-66.

3.6.2 Splicing

Perform splices in accordance with ACI 318 and ACI SP-66.

3.6.3 Supports

Secure reinforcement in place by the use of metal or concrete supports, spacers, or ties.

3.7 EMBEDDED ITEMS

Before placing concrete, take care to determine that all embedded items are firmly and securely fastened in place. Provide embedded items free of oil and other foreign matter, such as loose coatings of rust, paint and scale. Embedding of wood in concrete is permitted only when specifically authorized or directed.

3.8 TESTING AND INSPECTING

Report the results of all tests and inspections conducted at the project site informally at the end of each shift. Submit written reports weekly. Deliver within three days after the end of each weekly reporting period.

3.8.1 Field Testing Technicians

The individuals who sample and test concrete must have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.8.2 Preparations for Placing

Inspect foundation or construction joints, forms, and embedded items in sufficient time prior to each concrete placement to certify that it is ready to receive concrete.

3.8.3 Sampling and Testing

e. Obtain samples and test concrete for quality control during placement. Sample fresh concrete for testing in accordance with ASTM C172/C172M. Make six test cylinders.

f. Test concrete for compressive strength at 7 and 28 days for each design mix and for every 100 cubic yards of concrete. Test two cylinders at 7 days; two cylinders at 28 days; and hold two cylinders in reserve. Conform test specimens to ASTM C31/C31M. Perform compressive strength testing conforming to ASTM C39/C39M.

g. Test slump at the site of discharge for each design mix in accordance with ASTM C143/C143M. Check slump once during each shift that concrete is produced.

h. Test air content for air-entrained concrete in accordance with ASTM C231/C231M. Test concrete using lightweight or extremely porous aggregates in accordance with ASTM C173/C173M. Check air content at least once during each shift that concrete is placed.

i. Determine temperature of concrete at time of placement in accordance with ASTM C1064/C1064M. Check concrete temperature at least once during each shift that concrete is placed.

3.8.4 Action Required

3.8.4.1 Placing

Do not begin placement until the availability of an adequate number of acceptable vibrators, which are in working order and have competent operators, has been verified. Discontinue placing if any lift is inadequately consolidated.

3.8.4.2 Air Content

Whenever an air content test result is outside the specification limits, adjust the dosage of the air-entrainment admixture prior to delivery of concrete to forms.

3.8.4.3 Slump

Whenever a slump test result is outside the specification limits, adjust the batch weights of water and fine aggregate prior to delivery of concrete to the forms. Make the adjustments so that the water-cementitious material ratio does not exceed that specified in the submitted concrete mixture proportion and the required concrete strength is still met.

-- End of Section --

SECTION 26 05 00.00 40: COMMON WORK RESULTS FOR ELECTRICAL
11/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1 (2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16 (2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM D709 (2017) Standard Specification for Laminated Thermosetting Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 480 (1981) Toggle Switches INSTITUTE OF

ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2023) National Electrical Safety Code

IEEE C57.12.28 (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity

IEEE C57.12.29 (2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

IEEE Stds Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions INTERNATIONAL CODE

COUNCIL (ICC)

ICC/ANSI A117.1 (2009) Accessible and Usable Buildings and Facilities

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C12.7	(2022) Requirements for Watthour Meter Sockets
ANSI C80.1	(2020) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2020) American National Standard for Electrical Metallic Tubing (EMT)
ANSI Z535.1	(2017) Safety Colors
ANSI/NEMA OS 1	(2013; R 2020) Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
ANSI/NEMA OS 2	(2013; R 2020) Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA AB 3	(2013) Molded Case Circuit Breakers and Their Application
NEMA FB 1	(2014) Standard for Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable
NEMA FU 1	(2012) Low Voltage Cartridge Fuses
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA TC 2	(2020) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2021) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA VE 1	(2017) Metal Cable Tray Systems
NEMA WD 1	(1999; R 2020) Standard for General Color Requirements for Wiring Devices

NEMA WD 6	(2021) Wiring Devices Dimensions Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 70E	(2024) Standard for Electrical Safety in the Workplace

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-222	(2018H; Add 1 2019) Structural Standard for Antenna Supporting Structures and Antennas and Small Wind Turbine Support Structures

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jan 2022) UL Standard for Safety Flexible Metal Conduit
UL 4	(2004; Reprint Mar 2021) UL Standard for Safety Armored Cable
UL 5	(2016; Reprint Jul 2022) UL Standard for Safety Surface Metal Raceways and Fittings
UL 5A	(2015; Reprint Aug 2020) Nonmetallic Surface Raceways and Fittings
UL 6	(2022) UL Standard for Safety Electrical Rigid Metal Conduit-Steel
UL 20	(2018; Reprint May 2023) UL Standard for Safety General-Use Snap Switches
UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint May 2023) UL Standard for Safety Panelboards
UL 83	(2017; Reprint Mar 2020) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 198M	(2018; Reprint May 2023) UL Standard for Mine-Duty Fuses
UL 360	(2013; Reprint Apr 2023) UL Standard for Safety Liquid-Tight Flexible Metal Conduit
UL 486A-486B	(2018; Reprint May 2021) UL Standard for

	Safety Wire Connectors
UL 486C	(2018; Reprint May 2021) UL Standard for Safety Splicing Wire Connectors
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 498	(2017; Reprint May 2023) UL Standard for Safety Attachment Plugs and Receptacles
UL 506	(2017; Reprint Jan 2022) UL Standard for Safety Specialty Transformers
UL 514A	(2013; Reprint Jun 2022) UL Standard for Safety Metallic Outlet Boxes
UL 514B	(2012; Reprint May 2020) Conduit, Tubing and Cable Fittings
UL 514C	(2014; Reprint Feb 2020) UL Standard for Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 651	(2011; Reprint May 2022) UL Standard for Safety Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL 797	(2007; Reprint Apr 2023) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 817	(2015; Reprint May 2023) UL Standard for Safety Cord Sets and Power-Supply Cords
UL 869A	(2006; Reprint Jun 2020) Reference Standard for Service Equipment
UL 870	(2016; Reprint Mar 2019) UL Standard for Safety Wireways, Auxiliary Gutters, and Associated Fittings
UL 943	(2016; Reprint Feb 2018) UL Standard for Safety Ground-Fault Circuit-Interrupters
UL 1242	(2006; Reprint Apr 2022) UL Standard for Safety Electrical Intermediate Metal Conduit -- Steel
UL 1283	(2017) UL Standard for Safety Electromagnetic Interference Filters
UL 1449	(2021; Reprint Dec 2022) UL Standard for Safety Surge Protective Devices
UL 1561	(2011; Reprint Jun 2015) Dry-Type General Purpose and Power Transformers
UL 1569	(2018) UL Standard for Safety Metal-Clad

	Cables
UL 4248-1	(2022) UL Standard for Safety Fuseholders - Part 1: General Requirements
UL 4248-12	(2018; Reprint Feb 2022) UL Standard for Safety Fuseholders - Part 12: Class R

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings Marking Strips;

SD-03 Product Data

Conduits and Raceways; Wire and Cable;

Splices and Connectors;

Outlet Boxes, Pull Boxes and Junction Boxes; Circuit Breakers;

Panelboards;

Dry-Type Distribution Transformers;

Device Plates;

SD-06 Test Reports

Continuity Test;

Phase-Rotation Tests;

Insulation Resistance Test;

600-Volt Wiring Test;

Transformer Tests;

Ground-Fault Receptacle Test; Insulation-Resistance Test;

SD-08 Manufacturer's Instructions

1.4 QUALITY CONTROL

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contractor/Buyer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, [IEEE C2] unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

2.1 EQUIPMENT

Provide the standard cataloged materials and equipment of manufacturers regularly engaged in the manufacture of the products. For material, equipment, and fixture lists submittals, show manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site.

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray, and equipment located outdoors: ANSI[Light Gray][Dark Gray].

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED MOUNTING.

2.1.1 Conduits and Raceways

2.1.1.1 Rigid Steel Conduit

Provide hot dipped galvanized rigid steel conduit complying with NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable. Except where installed underground, or in corrosive areas, provide polyvinylchloride (PVC), or protect from corrosion by painting with bitumastic coating or wrapping with corrosion inhibiting tape..

Use threaded fittings for rigid steel conduit.

Use solid gaskets. Ensure conduit fittings with blank covers have gaskets, except in clean, dry areas or at the lowest point of a conduit run where drainage is required.

Provide covers with captive screws and are accessible after the work has been completed.

2.1.1.2 Electrical Metallic Tubing (EMT)

Ensure EMT is in accordance with UL 797, UL 5, and ANSI C80.3 and is zinc coated steel. Provide zinc-coated couplings and connectors that are raintight, [gland] compression type with insulated throat. Crimp, spring, or setscrew type fittings are not acceptable.

2.1.1.3 Flexible Metallic Conduit

Ensure flexible metallic conduit is galvanized steel and complies with UL 1 and UL 360.

Ensure fittings for flexible metallic conduit are specifically designed for such conduit.

Provide liquid-tight flexible metallic conduit with a protective jacket of PVC extruded over a flexible interlocked galvanized steel core to protect wiring against moisture, oil, chemicals, and corrosive fumes.

Ensure fittings for liquid-tight flexible metallic conduit are specifically designed for such conduit.

2.1.1.4 Intermediate Metal Conduit

Ensure intermediate metal conduit is galvanized steel and complies with UL 1242, NEMA RN 1, ANSI C80.1, UL 6 and UL 5 as applicable.

2.1.1.5 Rigid Nonmetallic Conduit

Ensure rigid nonmetallic conduit complies with NEMA TC 2, NEMA TC 3, and UL 651 as applicable with a wall thickness not less than Schedule 40.

2.1.1.6 Surface Metal Raceway

Ensure surface metal raceways and multi-outlet assemblies conform to NFPA 70, and have receptacles conforming to NEMA WD 1, Type [5-15R] [5-20R].

UL 5, two-piece painted steel, totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated.

2.1.1.7 Surface Nonmetallic Raceway

UL 5A, nonmetallic totally enclosed, snap-cover type. Provide multiple outlet-type raceway with grounding-type receptacle where indicated.

2.1.2 Wireways

Ensure wireways and auxiliary gutters are a minimum 4 by 4-inch trade size conforming to UL 870.

UL 870. Material: steel epoxy painted 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with[hinged-][screw-] cover NEMA[1][3R][12] enclosure per NEMA ICS 6.

]2.1.4 Outlet Boxes, Pull Boxes and Junction Boxes

Ensure outlet boxes for use with conduit systems are in accordance with NEMA FB 1 UL 514A, UL 514B, UL 514C and [ANSI/NEMA OS 1] [ANSI/NEMA OS 2] and are not less than 1½ inches deep. Furnish all pull and junction boxes with screw-fastened covers.

2.1.5 Panelboards

Provide panelboards in accordance with NEMA PB 1, UL 67, and UL 50. Ensure panelboards for use as service equipment are also in accordance with UL 869A. Ensure panelboards have current rating, number of phases, and number of wires as indicated or specified herein. Ensure panelboards are rated for 277/480-volt, three-phase, 60-hertz. Ensure each panelboard, as a complete unit, has a short-circuit current rating equal to or greater than the integrated equipment rating indicated, but in no case less than 10,000 amperes symmetrical.

Provide panelboards with bolt-on circuit breakers only. Use of plug-in style breaker is not permitted. Ensure panelboards are designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining required clearance. Provide main lugs or main circuit breakers mounted["above"][or]["below"] branch breakers with current ratings as indicated. Use of sub-feed breakers is not acceptable unless specifically indicated otherwise. Where "space only" is indicated, make provisions for future installation of breakers.

Submit detail drawings and manufacturer's standard product data for panelboards. Detail drawings consist of fabrication and assembly drawings for all parts of the work in sufficient detail to verify conformity with all requirements. Ensure drawings for panelboards indicate details of bus layout, overall physical features, dimensions, ratings, service requirements, and weights of equipment.

Provide[[tinned] copper][aluminum] buses of the rating indicated, with main lugs or main circuit breaker. Provide all panelboards for use on grounded ac systems with a separate grounding bus in accordance with UL 67 bonded to the panelboard enclosure. Provide three-phase, four-wire and single-phase, three-wire panelboards with an isolated full-capacity bus providing spaces for single-pole circuit breaker switches and spaces indicated as spare.

Provide bus bar connections to the branch circuit breakers that are the "distributed phase" or "phase sequence" type. Ensure single-phase, three-wire panelboard busing is such that when any two adjacent single-pole breakers are connected to opposite phases, two-pole breakers can be installed in any location. Ensure that three-phase, four-wire panelboard busing is such that when any three adjacent single-pole breakers are individually connected to each of the three different phases, two- or three-pole breakers can be installed at any location. Ensure current-carrying parts of the bus assembly are plated.

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping.

2.1.5.1 Circuit Breakers

Provide circuit breakers that conform to UL 489 and NEMA AB 3 [and as specified in Section 26 05 71.00 40 LOW VOLTAGE OVERCORRECT PROTECTIVE DEVICES]with frame a trip ratings as indicated.

Provide bolt-on type, molded-case, manually operated, trip-free circuit breakers, with inverse-time thermal-overload protection and instantaneous magnetic short-circuit protection. Completely enclose circuit breakers in a molded case, with a factory-sealed, calibrated sensing element to prevent tampering. Plug-in type, tandem, and half-size circuit breakers are not permitted.

Provide inverse-time-delay thermal-overload protection and instantaneous magnetic short-circuit protection. Provide an instantaneous [thermal-magnetic][electronic][solid-state] tripping element that is adjustable and accessible from the front of the breaker on frame sizes larger than [100][250][_____] ampere.[Provide circuit breakers with frame sizes [100][250][_____] ampere and larger with [electronic][solid-state] trip units equipped with adjustable long-time[,][short-time][and][ground-fault] settings in addition to instantaneous.]

Provide sufficient interrupting capacity of the panel and lighting branch circuit breakers to successfully interrupt the maximum short-circuit current imposed on the circuit at the breaker terminals. Provide circuit breaker interrupting capacities with a minimum of 10,000 A and that conform to NEMA AB 3. Series rating of circuit breakers or overcurrent protective devices to achieve indicated interrupt rating is [not]permitted.

Provide the common-trip-type multipole circuit breakers having a single operating handle and a two-position on/off indication. Provide circuit breakers with temperature compensation for operation in an ambient temperature of 104 degrees F. Provide circuit breakers that have root mean square (rms) symmetrical interrupting ratings sufficient to protect the circuit being supplied. Interrupting ratings may have selective-type tripping (time delay, magnetic, thermal, or ground fault).

Provide a phenolic-composition breaker body capable of having such accessories as handle-extension, handle-locking, and padlocking devices attached where required to meet lock-out/tag-out requirements of NFPA 70E.

2.1.6 Dry-Type Distribution Transformers

2.1.6.1 General Requirements

Ensure that general purpose dry-type transformers with windings 600 volts or less are two-winding, 60 hertz, and self-cooled in accordance with UL

506 and UL 1561. Ensure windings have a minimum of two 2-1/2-percent taps above and below nominal voltage.

Provide transformers in NEMA[1][3R][_____] enclosure. Transformer insulation system:

a. 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding[150][115][80] degrees C under full-rated load in maximum ambient of 40 degrees C.

b. 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding[150][115][80] degrees C under full-rated load in maximum ambient of 40 degrees C.

2.1.6.2 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

2.2 MATERIALS

2.2.1 Wire And Cable

Provide wires and cables in accordance with applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

Ensure connectors used in wire systems comply with UL 486A-486B and UL 486C as applicable.

Ensure conductors installed in plenums are marked plenum rated.

2.2.1.1 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts,[Type THWN/THHN conforming to UL 83][or][Type[XHHW][or][RHW] conforming to UL 44], except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.2.2 Device Plates Provide the following:

a. UL listed, one-piece device plates for outlets to suit the devices installed.

b. For metal outlet boxes, plates on unfinished walls: zinc-coated sheet steel or cast metal having round or beveled edges.

c. For nonmetallic boxes and fittings, other suitable plates may be provided.

g. Sectional type device plates are not permitted.

h. Plates installed in wet locations: gasketed and UL listed for "wet locations."

2.2.3 Switches

2.2.3.1 Safety Switches

Ensure safety switches comply with NEMA KS 1, and are the heavy-duty type with enclosure, voltage, current rating, number of poles, and fusing as indicated on the drawings. Ensure fused switch fuse holders comply with UL 4248-1. Ensure switch construction is such that, when the switch handle in the "ON" position, the cover or door cannot be opened. Cover release device is coin proof and so constructed that an external tool is used to open the cover. Make provisions to lock the handle in the "OFF" position. Ensure the switch is not capable of being locked in the "ON" position.

Provide switches of the quick-make, quick-break type and terminal lugs for use with copper conductors.

Ensure safety color coding for identification of safety switches conforms to ANSI Z535.1.

2.2.3.2 Toggle Switches

Ensure toggle switches comply with EIA 480, NEMA WD 1, and UL 20 control Light Emitting Diode (LED), and fluorescent lighting fixtures and are the heavy duty, general purpose, noninterchangeable flush-type.

Provide commercial grade toggle switches, [single] [double]-pole, [three] [four]-way two-position devices rated 20 amperes at 120/277 volts, 60 hertz alternating current (ac) only.

Ensure all toggle switches are products of the same manufacturer.

2.2.4 Fuses

NEMA FU 1. Provide complete set of fuses for each fusible[switch][panel][and control center]. Coordinate time-current characteristics curves of fuses serving motors or connected in series with circuit breakers[or other circuit protective devices] for proper operation. Submit coordination data for approval. Provide fuses with a voltage rating not less than circuit voltage.

2.2.4.1 Fuseholders

Provide in accordance with UL 4248-1.

2.2.4.2 Cartridge, Current Limiting Type (Class R)

UL 198M, Class[RK-1][RK-5][time-delay type]. Provide only Class R associated fuseholders in accordance with UL 4248-12.

2.2.4.3 Cartridge Fuses, High-Interrupting Capacity, Current Limiting Type (Classes J, L, and CC)

UL 198M, Class J for zero to 600 amperes, Class L for 601 to 6,000 amperes, and Class CC for zero to 30 amperes.

2.2.4.4 Cartridge Fuses, Current Limiting Type (Class T)

UL 198M, Class T for zero to 1,200 amperes, 300 volts; and zero to 800 amperes, 600 volts.

2.2.5 Receptacles Provide the following:

a. [UL 498, hard use (also designated heavy-duty),][UL 498, hospital grade,] grounding-type.

b. Ratings and configurations: as indicated.

c. Bodies: [white][ivory][brown] as per NEMA WD 1.

d. Face and body: thermoplastic supported on a metal mounting strap.

e. Dimensional requirements: per NEMA WD 6.

f. Screw-type, side-wired wiring terminals or of the solderless pressure type having suitable conductor-release arrangement.

g. Grounding pole connected to mounting strap.

h. The receptacle: containing triple-wipe power contacts and double or triple-wipe ground contacts.

2.2.5.1 Switched Duplex Receptacles

Provide separate terminals for each ungrounded pole. Top receptacle: switched when installed.

2.2.5.2 Weatherproof Receptacles

Provide receptacles, UL listed for use in "wet locations." Include cast metal box with gasketed, hinged, lockable and weatherproof while-in-use, [polycarbonate, UV resistant/stabilized][die-cast metal/aluminum] cover plate.

2.2.5.3 Ground-Fault Circuit Interrupter Receptacles

UL 943, duplex type for mounting in standard outlet box. Provide device capable of detecting current leak of 6 milliamperes or greater and tripping per requirements of UL 943 for Class A ground-fault circuit interrupter devices. Provide screw-type, side-wired wiring terminals or pre-wired (pigtail) leads.

2.2.6 Manufacturer's Nameplate

Ensure each item of equipment has a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable.

2.2.7 Warning Signs

Provide warning signs for the enclosures of electrical equipment including substations, pad-mounted transformers, pad-mounted switches, generators, and switchgear having a nominal rating exceeding 600 volts.

a. Enclosure integrity to conform with [IEEE C57.12.28][IEEE C57.12.29], such as for pad-mounted transformers[and pad-mounted SF6 switches]. Provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Provide decal signs with nominal dimensions of 7 by 10 inches. Print the legend "DANGER HIGH VOLTAGE" in two lines of nominal 2-inch high letters. Show the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background.[Use Panduit decal No. PPSO710D72 or approved equal.]

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3-inch high white letters on a red and black field.

2.2.9 Surge Protective Devices

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance[, load centers] [, panelboards] [, MCC] [and] [_____]. Provide surge protectors in a NEMA[1][______] enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N) [Neutral to ground (N-G)]
[Phase to ground (L-G)]

[FOR DELTA CONNECTIONS-
Phase to phase (L-L) Phase to ground (L-G)

] SPDs at the service entrance: provide with a minimum surge current rating of 80,000 amperes for L-L mode minimum and 40,000 amperes for other modes (L-N, L-G, and N-G)[and downstream SPDs rated 40,000 amperes for L-L mode minimum and 20,000 amperes for other modes (L-N, L-G, and N-G)].

[Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, L-G, and N-G Voltage Protection Rating:

[600V for 120V, single phase system] [600V for 120/240V, single phase system] [600V for 208Y/120V, three phase system] [1,200V for 480Y/277V, three phase system] Maximum L-L Voltage

Protection Rating:

[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]

[1,200V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

][Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:
[700V for 120V, single phase system]
[700V for 120/240V, single phase system]
[700V for 208Y/120V, three phase system]
[1,200V for 480Y/277V, three phase system]

Maximum L-L Voltage Protection Rating:
[1,200V for 120V, single phase system]
[1,200V for 120/240V, single phase system]
[1,200V for 208Y/120V, three phase system]
[2,000V for 480Y/277V, three phase system]

] The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

PART 3 EXECUTION

3.1 PREPARATION

Submit manufacturer's instructions including special provisions required to install equipment components and system packages. Special provisions include impedances, hazards and safety precautions.

Protect metallic materials against corrosion. Provide equipment enclosures with the standard finish by the manufacturer when used for most indoor installations. Do not use aluminum when in contact with earth or concrete and, where connected to dissimilar metal, protect by using approved fittings and treatment. Except where other equivalent protective treatment is specifically approved in writing, provide hot-dip galvanized ferrous metals for items such as, anchors, bolts, braces, boxes, bodies, clamps, fittings, guards, nuts, pins, rods, shims, thimbles, washers, and miscellaneous items not made of corrosion-resistant steel.

3.2 INSTALLATION

3.2.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.2.2 Hazardous Locations

Perform work in hazardous locations, as defined by NFPA 70, in strict accordance with NFPA 70 for particular "Class," "Division," and "Group" of hazardous locations involved. Provide conduit and cable seals where required by NFPA 70. Provide conduit with tapered threads.

3.2.3 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.2.4 Labels

Wherever work results in service entrance, disconnect devices in more than one enclosure, as permitted by NFPA 70, label each enclosure, new and existing, as one of several enclosures containing service entrance disconnect devices. Label, at minimum: indicate number of service disconnected devices housed by enclosure and indicate total number of enclosures that contain service disconnect devices. Provide laminated plastic labels conforming to paragraph FIELD FABRICATED NAMEPLATES. Use lettering of at least 0.25 inch in height, and engrave on black-on-white matte finish. Service entrance disconnect devices in more than one enclosure: provided only as permitted by NFPA 70.

3.2.5 Wiring Methods

Provide insulated conductors installed in rigid steel conduit, IMC, rigid nonmetallic conduit, or EMT, except where specifically indicated or specified otherwise or required by NFPA 70 to be installed otherwise. Grounding conductor: separate from electrical system neutral conductor. Provide insulated green equipment grounding conductor for circuit(s) installed in conduit and raceways.[Shared neutral, or multi-wire branch circuits, are not permitted with arc-fault circuit interrupters.] Minimum conduit size: 1/2 inch in diameter for low voltage lighting and power circuits. Vertical distribution in multiple story buildings made with metal conduit in fire-rated shafts, with metal conduit extending through shafts for minimum distance of 6 inches.

3.2.5.1 Pull Wire

Install pull wires in empty conduits. Pull wire: plastic having minimum 200-pound force tensile strength. Leave minimum 36 inches of slack at each end of pull wire.

3.2.7 Conduits, Raceways and Fittings

Ensure that conduit runs between outlet and outlet, between fitting and fitting, or between outlet and fitting does not contain more than the equivalent of three 90-degree bends, including those bends located immediately at the outlet or fitting.

Do not install crushed or deformed conduit. Avoid trapped conduit runs where possible. Take care to prevent the lodgment of foreign material in the conduit, boxes, fittings, and equipment during the course of construction. Clear any clogged conduit of obstructions or replace conduit.

3.2.7.1 Rigid Steel Conduit

Make field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use long radius conduit for elbows larger than 2½ inches.

Provide a flush coupling for all conduit stubbed-up through concrete floors for connections to free-standing equipment with the exception of motor-control centers, cubicles, and other such items of equipment, when the floor slab is of sufficient thickness. Otherwise, provide a floor box set flush with the finished floor. For conduits installed for future use, terminate with a coupling and plug; set flush with the floor.

3.2.7.2 Electrical Metallic Tubing (EMT)

Ground EMT in accordance with NFPA 70, using pressure grounding connectors especially designed for EMT.

3.2.7.3 Flexible Metallic Conduit

Use flexible metallic conduit to connect recessed fixtures from outlet boxes in ceilings, transformers, and other approved assemblies.

Use bonding wires in flexible conduit as specified in NFPA 70, for all circuits. Flexible conduit is not considered a ground conductor.

Make electrical connections to vibration-isolated equipment with flexible metallic conduit.

Use liquid-tight flexible metallic conduit in wet and oily locations and to complete the connection to motor-driven equipment.

Provide flexible steel conduit between 3 and 6 feet in length for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: ½-inch diameter. Provide liquid-tight flexible[nonmetallic] conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement, or motors. Provide separate ground conductor across flexible connections.

3.2.7.4 Intermediate Conduit

Make all field-made bends and offsets with approved Hickey bending tool or conduit bending machine. Use intermediate metal conduit only for indoor installations.

3.2.7.5 Rigid Nonmetallic Conduit

Install a green insulated copper grounding conductor in conduit with conductors and solidly connect to ground at each end. Size grounding wires in accordance with NFPA 70.

3.2.7.6 Underground Conduit

Plastic-coated rigid steel; plastic-coated steel IMC; PVC, Type EPC-40[; or fiberglass.

3.2.7.7 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit or IMC only.

3.2.7.8 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners.

3.2.7.9 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.2.8 Wiring

Color code feeder and branch circuit conductors as follows:

CONDUCTOR	COLOR AC
Phase A	Black (208VAC); Brown (480VAC)
Phase B	Red (208VAC); Orange (480VAC)
Phase C	Blue (208VAC); Yellow (480VAC)
Neutral	White (208VAC); Natural Gray (480VAC)
Equipment Grounds	[Green] [Green with Yellow

Use conductors up to and including AWG No. 2 that are manufactured with colored insulating materials. For conductors larger than AWG No. 2, have ends identified with color plastic tape in outlet, pull, or junction boxes.

Splice in accordance with the NFPA 70. Provide conductor identification within each enclosure where a tap, splice, or termination is made and at the equipment terminal of each conductor. Match terminal and conductor identification as indicated.

Where several feeders pass through a common pull box, tag the feeders to clearly indicate the electrical characteristics, circuit number, and panel designation.

3.2.9 Wiring Devices

3.2.9.1 Wall Switches and Receptacles

Install wall switches and receptacles so that when device plates are applied, the plates are aligned vertically to within [_____] [1/16] inch.

Bond ground terminal of each flush-mounted receptacle to the outlet box with an approved green bonding jumper when used with dry wall type construction.

3.2.9.2 Device Plates

Ensure device plates for switches are suitably engraved with a description of the loads when not within sight of the loads controlled.

Mark device plates and receptacle cover plates for receptacles other than 125-volt, single-phase, duplex, convenience outlets. Show the circuit number, voltage, frequency, phasing, and amperage available at the receptacle. Use self-adhesive labels having [______] [1/4] inch embossed letters.

Similarly mark device plates for convenience outlets indicating the supply panel and circuit number.

3.2.10 Splices and Connectors

Make all splices in AWG No. 8 and smaller with approved [insulated electrical type] [indentor crimp-type connectors and compression tools].

Make all splices in AWG No. 6 and larger with [indentor crimp-type connectors and compression tools][insulated electrical lugs type] . Wrap joints with an insulating tape that has an insulation and temperature rating equivalent to that of the conductor.

3.2.11 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves.

3.2.11.1 Marking Strips

Provide marking strips in accordance with the following:

a. Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations.

b. Use permanent ink for the wire numbers

c. Provide reversible marking strips to permit marking both sides or provide two marking strips with each block.

d. Size marking strips to accommodate the two sets of wire numbers.

e. Assign a device designation in accordance with NEMA ICS 1 to each device to which a connection is made. Mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Subcontractor's schematic and connection diagrams.

f. The wire (terminal point) designations used on the Subcontractor's wiring diagrams and printed on terminal block marking strips may be according to the Subcontractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Contractor/Buyer's wire designations.

g. Prints of the marking strips drawings submitted for approval will be so marked and returned to the Subcontractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

3.2.12 Safety Switches

Securely fasten switches to the supporting structure or wall, utilizing a minimum of [four] [_____] ¼-inch bolts. Do not use sheet metal screws and small machine screws for mounting. Do not mount switches in an inaccessible location or where the passageway to the switch may become obstructed. Mounting height [______] [5] feet above floor level, when possible.

3.2.13 Boxes and Fittings

Provide pull boxes where necessary in the conduit system to facilitate conductor installation. For conduit runs longer than [______] [100] feet or with more than three right-angle bends, install a pull box at a convenient intermediate location.

Securely mount boxes and enclosures to the building structure using supports that are independent of the conduit entering or leaving the boxes.

3.2.14 Covers and Device Plates

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Install plates with alignment tolerance of 1/16 inch. Use of sectional-type device plates are not permitted. Provide gasket for plates installed in wet locations.

3.2.15 Panelboards

Securely mount panelboards so that the top operating handle does not exceed [_] [72]-inches above the finished floor. Do not mount equipment within
36-inches of the front of the panel. Ensure directory card information is complete and legible.

3.2.16 Dry-Type Distribution Transformers

Connect dry-type transformers with flexible metallic conduit.

Mount all dry-type transformers on vibration isolators

]3.2.18 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet.

3.2.19 Field Fabricated Nameplates

Ensure nameplates conform to ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device, as specified or as indicated on the drawings. Each nameplate inscription identifies the function and, when applicable, the position. Provide nameplates that are melamine plastic, 0.125-inch thick, white with [black] [_____] center core and a matte finish surface [with square corners]. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 by 2.5 inches. Lettering is a minimum of 0.25-inch high normal block style.

3.2.20 Identification Plates and Warnings

Provide identification plates for lighting and power panelboards, motor control centers, all line voltage heating and ventilating control panels, fire detector and sprinkler alarms, doorbells, pilot lights, disconnect switches, manual starting switches, and magnetic starters. Attach identification plates to process control devices and pilot lights.

Install identification plates for all line voltage enclosed circuit breakers, identifying the equipment served, voltage, phase(s) and power source. For circuits 480 volts and above, install conspicuously located warning signs in accordance with OSHA requirements.

3.3 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 FIELD APPLIED MOUNTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. [Where field painting of enclosures for panelboards, load centers or the like is specified to match adjacent surfaces, to correct damage to the manufacturer's factory applied coatings, or to meet the indicated or specified safety criteria, provide manufacturer's recommended coatings and apply in accordance to manufacturer's instructions.]

3.6 FIELD QUALITY CONTROL

After completion of the installation and splicing, and prior to energizing the conductors, perform wire and cable continuity and insulation tests as herein specified before the conductors are energized.

Provide all necessary test equipment, labor, and personnel to perform the tests, as specified herein.

Isolate completely all wire and cable from all extraneous electrical connections at cable terminations and joints. Use substation and switchboard feeder breakers, disconnects in combination motor starters, circuit breakers in panel boards, and other disconnecting devices to isolate the circuits under test.

Perform insulation-resistance test on each field-installed conductor with respect to ground and adjacent conductors. Applied potential is 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. Take readings after 1 minute and until the reading is constant for 15 seconds. Minimum insulation-resistance values is not less than 25 Megohms for 300 volt rated cable and 100 Megohms for 600 volt rated cable. For circuits with conductor sizes AWG No. 8 and smaller insulation resistance testing is not required.

Perform continuity test to insure correct cable connection end-to-end (i.e., correct phase conductor, grounded conductor, and grounding conductor wiring). Repair and verify any damages to existing or new electrical equipment resulting from mis-wiring. Receive approval for all repairs prior to commencement of the repair.

Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment in a clockwise direction, facing the source.

Perform 600-volt wiring test on wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

Perform the standard, not optional, transformer tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

Perform ground-fault receptacle test for ground-fault receptacles with a "load" (such as a plug-in light) to verify that the "line" and "load" leads are not reversed.

Submit test reports in accordance with referenced standards in this section.

Final acceptance requires the successful performance of wire and cable under test. Do not energize any conductor until the final test reports are reviewed and approved.

-- End of Section --

SECTION 26 05 26.00 40: GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
08/19

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS A3.0M/A3.0	(2020) Standard Welding Terms and Definitions
AWS A5.8/A5.8M	(2019) Specification for Filler Metals for Brazing and Braze Welding
AWS B2.1/B2.1M	(2021) Specification for Welding Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B8	(2011; R 2017) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI/NEMA GR 1	(2007) Grounding Rod Electrodes and Grounding Rod Electrode Couplings

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-607	(2019d) Generic Telecommunications Bonding and Grounding (Earthing) for Customer

Premises

U.S. DEPARTMENT OF DEFENSE (DOD)

MIL-STD-889	(2021; Rev D) Galvanic Compatibility of Electrically Conductive Materials

UNDERWRITERS LABORATORIES (UL)

UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 546	(2008) UL Outline of Investigation for Conductor Termination Compounds

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-11 Closeout Submittals Record Drawings

1.3 QUALITY CONTROL

1.3.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contractor/Buyer. Ensure equipment, materials, installation, and workmanship are in accordance with the mandatory and advisory provisions of NFPA 70, IEEE C2 unless more stringent requirements are specified or indicated.

1.3.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Provide products which have been in satisfactory commercial or industrial use for 2 years prior to bid opening. Ensure the 2-year period includes applications of equipment and materials under similar circumstances and of similar size. Ensure the product has been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer.

PART 2 PRODUCTS

Submit material, equipment, and fixture lists for grounding systems, including manufacturer's style or catalog numbers, specification and drawing reference numbers, warranty information, and fabrication site information.

2.1 MATERIALS

2.1.1 Ground Rods

Provide ground rods of [copper][copper-clad steel] conforming to UL 467 and ANSI/NEMA GR 1. Ensure ground rods are not less than ¾ inch in diameter and 10 feet in length.

Where ground rod length is greater than 10 feet, provide sectional type ground rods with each section 10 feet in length. Join sectional type ground rods using [threaded brass couplings][exothermic welding completely around both rod/coupling joints][threaded couplings that are welded at the threaded joints]. Ensure ground rods have cone-shaped point on the end of the first section driven into the ground.

Provide ground rods and ground rod sections die-stamped near the top with the name or trademark of the manufacturer and the length of the segment in feet.

2.1.2 Ground Wires

2.1.2.1 Bare

Provide annealed bare copper, Class "B" stranded ground and bond wires in accordance with ASTM B8 for wires #4 AWG and larger and solid in accordance with ASTM B3 for wires #6 AWG and smaller. Provide conductors with 98 percent conductivity and sized wires in accordance with the requirements of NFPA 70 and NFPA 780.

2.1.2.2 Insulated

Ensure insulated conductors conform to the requirements of Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL.

Where installed in conduit as part of a complete circuit provide conductors with green insulation for sizes #8 AWG and smaller and with green phase tape at each end and in each junction box for sizes #6 AWG and larger.

2.1.2.3 Straps/Jumpers

Provide copper bonding straps and jumpers with a cross-sectional area of not less than [No. 6 AWG][as indicated]. Ensure bonding straps and jumpers for shock-mounted devices with [pivot] [hinged] [swivel] joints are made of [flat] [tinned-copper] [woven-wire braid] [flexible stranded] wire.

2.1.3 Connectors and Fasteners

2.1.3.1 Exothermic Welds

Ensure the molds, materials and powder charges used to make exothermic welds are the standard product of a single manufacturer and listed by the manufacturer for use on the specific type, size, quantity and configuration of conductors to which the weld is applied.

2.1.3.2 Irreversible Compression Lugs

Provide irreversible compression lug type connectors manufactured from tin-plated copper and installed using a hydraulic compression tool and die to apply correct, uniformly distributed, circumferential pressure. Ensure tools and dies are as recommended by the irreversible compression lug type connector manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed onto the conductor. Apply irreversible compression lug type connectors in strict accordance with the manufacturer's written instructions and published installation instructions. Use 2-hole lug type connectors for connections to NEMA cable pads and bus bars, and single-hole connectors otherwise.

2.1.3.3 Mechanical

Provide split bolt and clamp style mechanical type connectors manufactured from [copper,][copper alloy,][or][bronze,] listed by the manufacturer as suitable for direct burial use. Ensure mechanical type connectors are applied in strict accordance with the manufacturer's published installation instructions.

2.1.3.4 Fasteners

Provide bolts, nuts, washers, lock washers, and associated fasteners used for grounding and bonding connections manufactured of [copper][bronze][tin plated tempered brass][stainless steel]. Where fasteners contact dissimilar metals, apply conductive oxide-inhibiting compound.

2.1.5 Conductive Corrosion Inhibiting Compounds

Provide conductive corrosion inhibiting compounds UL Listed in accordance with UL 546, listed by the manufacturer as suitable for the application, and suitable for all aluminum and copper conductor/connector applications. Ensure conductive corrosion inhibiting compounds inhibit oxidation at the conductor/connector interface and have no deleterious effect on the conductor/connector metal or EPDM, natural rubber, or polyethylene insulating materials.[

Provide gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic, and contain conductive grit. Ensure gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor/connector interface of compression connectors.][

Provide non-gritted conductive corrosion inhibiting compound that are non-petroleum based and non-toxic and contain no grit filler. Ensure non-gritted conductive corrosion inhibiting compound is specified by the manufacturer for application to the conductor/connector interface of mechanical connectors such as bolted joints, flat-to-flat contact surfaces, terminal and lug tongues, and grooves of bolted parallel connectors or clamps.]

2.1.6 Ground Buses

Provide [electro-tin plated,]solid copper ground buses conforming to ASTM B187/B187M with minimum dimensions of 0.25 inch thick, 4 inches wide, and 12 inches in length or as indicated. Ensure ground buses are equipped with two UL Recognized red 1000V rated insulated standoffs and stainless steel mounting brackets.

Provide Telecommunications Main Ground Buses and Telecommunications Ground Buses in meeting the standards of TIA-607.

Provide grounding buses with predrilled NEMA hole configuration as indicated.

PART 3 EXECUTION

3.1 INSTALLATION

Install grounding systems in accordance with NFPA 70, NFPA 780 and IEEE C2, and as indicated.

Bond exposed non-current-carrying metallic parts of electrical equipment and metallic raceway systems to ground.

Bond grounding conductors in metallic and non-metallic raceways to ground. Make ground connections at equipment and to ground rods as indicated. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems.

Bond wiring system neutrals to ground in accordance with the requirements of NFPA 70. Where ground fault protection is employed, ensure that connection of ground and neutral does not interfere with correct operation of fault protection. [

Counterpoise ground systems consist of a series of ground rods with a direct buried grounding conductor loop, configured to minimize the number of dead-ends, interconnecting the individual ground rods. Provide ground rods in the locations indicated.]

3.1.1 Ground Rods

[Install ground rods using a water jetting procedure.]

[Install ground rods so that the top of the rod is [4] [_____] inches above grade.

][Install ground rods so that the top of the rod is not less than [18] [______] inches below finished grade.

]3.1.2 Conductors

Install bare or insulated conductors as indicated. Install bare conductors where not specifically identified as bare or insulated except where installed in conduit with associated phase conductors. Install insulated conductors in conduit with insulation of the same material as the associated phase conductors with which it is installed.

Provide straps/jumpers across joints subject to vibration. Install strap/jumper such that vibration will not change its electrical characteristics. Apply strap/jumper to the metallic structure on each side of the joint; do not penetrate any adjacent parts. Install straps/jumpers in areas that are accessible for maintenance. Install strap/jumper such that it does not restrict the movement of the metallic structures to which it is connected. Install strap/jumper such that it does not weaken the metallic structures to which it is attached. Do not connect two or more straps/jumpers in series.

3.1.3 Counterpoise

Install No. [4/0] [______] AWG bare copper counterpoise grounding conductor direct buried outside of the structure drip line, within 24 to 72 inches of the structure foundation, with a minimum of 18 inches of earth cover. Install counterpoise grounding conductor in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the conductor.

Install ground rods vertically into the earth not less 10 feet with top of ground rod not less than [18] [______] inches below finished grade. Bond ground rods to counterpoise grounding conductor at intervals no less than 20 linear feet nor greater than 40 linear feet of ground counterpoise cable.

3.1.4 Ground Buses

Install ground busses in accordance with manufacturer's instructions.

3.1.5 Building Grounds

Install No. [4/0] [______] AWG bare copper ground conductor from [concrete encased foundation rebar][and][every corner column and intermediate exterior column] to counterpoise. [Connect conductors to rebar using [mechanical connectors manufactured for such purpose][exothermic welds]. Install one conductor a minimum of every [60] [____] feet of concrete foundation perimeter.]Connect ground conductors to [columns and]counterpoise using [mechanical connectors manufactured for such purpose][exothermic welds].

3.1.6 Equipment Grounding

Install ground systems for power, telecommunications, and instrumentation. Independently connect each system to the building counterpoise.

3.1.6.1 Equipment and Enclosure Bonding

Bond each metallic enclosure and all electrical equipment to ground. Make at least one copper connection from the system ground point to one or more enclosures in the area such that all enclosures and equipment provide a low-impedance path to ground when properly bonded together.

[In addition to the green colored equipment grounding conductor required in each raceway and sized in accordance with Table 250.122 of NFPA 70, bond each panelboard, switchboard enclosure, transformer housing, motor housing, disconnect, starter, and other electrical equipment, to the grounding system with a stranded copper conductor, routed external to the feeder raceway.

] Individually and directly connect indoor substations, transformers, switchboard frames, switchgear assemblies, motors, motor control centers, air compressors, air handlers, refrigerated air dryers, generators, frames and tracks of cranes, and [_____] to the building ground. Ensure the current-carrying capacity of the grounding conductor is the same as the current-carrying capacity of the power conductors for circuits utilizing power lines size No. [2] [_____] AWG and smaller. For circuits with power wiring larger than No. [2] [______] AWG, ensure the grounding conductor is in accordance with NFPA 70.

3.1.6.2 Bonding of Conduit and Raceway Systems

Bond all metal conduit, fittings, junction boxes, outlet boxes, armored and metal sheathed cable, and other raceways. Ensure adequate electrical contact at the joints and terminations. Ensure metallic raceway systems have electrical continuity with equipment. Individually and directly connect equipment to the building ground, independent of the raceway system.

For rigid metal conduit and terminations, ensure threaded connections are wrench-tight with no exposed threads. Ream all ends of the conduit to remove burrs and rough edges. Bond conduits entering boxes and enclosures to the box with [bonding-type locknuts, one outside and one inside.] [locknuts and grounding-type bushings.] Locknuts that gouge into the metal box when tightened are not acceptable.

Conduit systems that are interrupted by PVC dielectric links are bonded separately on either side of the link. Do not jumper the dielectric link.

Install flexible metal conduit with an integral grounding conductor.

3.1.6.3 Cable Tray Bonding

Bond cable tray sections together. Cable tray sections in tandem assembly are considered as having electrical continuity when these sections are bonded with the appropriate bolts. Install bond straps across expansion joints. Bond cable trays to the building ground system.

3.1.7 Bonding Materials And Methods

Accomplish bonding of metal surfaces by [brazing] [welding] [clamping] [structural joining methods].

3.1.7.1 Brazing

Ensure brazing solder conforms to AWS A5.8/A5.8M [_____].

3.1.7.2 Welding

Weld using the exothermic process with procedures conforming to AWS A3.0M/A3.0, AWS B2.1/B2.1M, and manufacturer's recommendation. Where dissimilar metals are to be joined via exothermic weld, follow the weld kit manufacturer's recommendations and published instructions. Ensure connections between dissimilar metals do not produce galvanic action in accordance with MIL-STD-889.

Use welding processes of the exothermic fusion type that makes a connection without corroding or loosening. Ensure process joins all strands and does not cause the parts to be damaged or weakened. Completed connection or joint is equal or larger in size than the conductors joined and has the same current-carrying capacity as the largest conductor. Paint the buried ground connections with a bitumastic paint.

3.1.7.3 Clamping

In external locations, use clamping only where a disconnect type of connection is required. Connection device may utilize [spring-loaded jaws] [threaded fasteners]. Construct device such that positive contact pressure is maintained at all times. Use machine bolts with [tooth-type] [spring-type] lock washers.

3.1.7.4 Cleaning of Bonding Surfaces

Thoroughly clean surfaces that comprise the bond before joining. Apply an appropriate abrasive with gentle and uniform pressure to ensure a smooth and uniform surface. Do not remove excessive metal from the surface. Clean clad metals in such a manner that the cladding material is not penetrated by the cleaning process. Then clean bare metal with an appropriate solvent to remove any grease, oil, dirt, corrosion preventives, and other contaminants. Bond to the cleaned area within one hour after cleaning. Seal joint and refinish the exposed surfaces within two hours of exposure to prevent oxidation. When additional time is required, apply a corrosion preventive compound until the area can be refinished.

3.1.7.5 Protection of Finished Bonds

Protect finished bonds by painting to match the original finish after the bond is made.

3.2 FIELD QUALITY CONTROL

Submit written results of each test to Contractor/Buyer for review and approval. Document each location where test is performed, the field conditions at the time of the test, the measured results of the test, and whether the measured results "PASSED" or "FAILED" relative to specified pass/fail performance criteria.

Perform rework to correct FAILED conditions at no additional cost to the Contractor/Buyer.

3.2.1 Ground Isolation Test

Test ground systems for isolation from other ground systems.

3.2.2 Equipment Continuity Test

Test connection from electrical distribution equipment including panelboards, switchboards, transformers, substations, and motor control centers to counterpoise. Measure and record the circuit resistance between electrical equipment ground connections and the counterpoise. The circuit resistance shall not exceed [5][ ] Ohms.

3.3 CLOSEOUT ACTIVITIES

Submit record drawings indicating the location of ground rods, mats, grids, building ground bus, supplementary grounding electrodes, steel building columns, and other metal structures connected to the grounding system.

-- End of Section --

SECTION 26 28 00.00 10: MOTOR CONTROL CENTERS, SWITCHBOARDS AND PANELBOARDS
08/22

PART 1 GENERAL

1.1 SUMMARY

These specifications include the design, fabrication, assembly, wiring, testing, and delivery of the items of equipment and accessories and spare parts listed in the Schedule and shown on the drawings.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)

ASTM INTERNATIONAL (ASTM)

ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B187/B187M	(2020) Standard Specification for Copper, Bus Bar, Rod and Shapes and General Purpose Rod, Bar and Shapes
ASTM B317/B317M	(2007; R 2015; E 2016) Standard Specification for Aluminum-Alloy Extruded Bar, Rod, Tube, Pipe, Structural Profiles, and Profiles for Electrical Purposes (Bus Conductor)
ASTM D877	(2002; R 2007) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D923	(2007) Standard Practice for Sampling Electrical Insulating Liquids
ASTM D924	(2008) Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

ASTM D971	(2020) Standard Test Method for Interfacial Tension of Insulating Liquids Against Water by the Ring Method
ASTM D974	(2014; E 2016) Standard Test Method for Acid and Base Number by Color-Indicator Titration
ASTM D1500	(2012; R 2017) Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
ASTM D1524	(2015; R 2022) Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field
ASTM D1533	(2012) Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.04	(2018; Erta 2019; Corr 2021) Ratings and Requirements for AC High-Voltage Circuit Breakers with Rated Maximum Voltage Above 1000 V Corrigendum 1
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C12.4	(1984; R 2011) Registers - Mechanical Demand
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NEMA PB 1	(2011) Panelboards
NEMA PB 2	(2011) Deadfront Distribution Switchboards
NEMA ST 20	(2014) Dry-Type Transformers for General Applications
NEMA/ANSI C12.10	(2011; R 2021) Physical Aspects of Watthour Meters - Safety Standard
NEMA/ANSI C12.11	(2006; R 2019) Instrument Transformers for Revenue Metering, 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

U.S. DEPARTMENT OF DEFENSE (DOD)

DOD 8510.01	(2022) Risk Management Framework (RMF) for DoD Systems
DODI 8500.01	(2014) Cybersecurity UNDERWRITERS

LABORATORIES (UL)

UL 44	(2018; Reprint May 2021) UL Standard for Safety Thermoset-Insulated Wires and Cables
UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 67	(2018; Reprint May 2023) UL Standard for Safety Panelboards
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 489	(2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 508	(2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment
UL 845	(2021) UL Standard for Safety Motor Control Centers
UL 891	(2019) UL Standard for Safety Switchboards
UL 1063	(2017; Reprint Jun 2022) UL Standard for Safety Machine-Tool Wires and Cables

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings;

Shop Drawings;

Switchboards; Panelboards;

SD-03 Product Data Equipment;

Required Settings Request For Settings

SD-06 Test Reports

Acceptance Checks And Tests;

1.4 DELIVERY, STORAGE, AND HANDLING

Ship the equipment as completely assembled and wired as feasible so as to require a minimum of installation work. Properly match mark each shipping section to facilitate reassembly,.

Carefully pack and ship separately any relay or other device which cannot withstand the hazards of shipment when mounted in place on the equipment. Mark these devices with the number of the panel which they are to be mounted on and fully identified. Wrap all finished painted surfaces and metal work or otherwise protect from damage during shipment. Prepare all parts for shipment so that slings for handling may be attached readily while the parts are in a railway car or transport truck. Carefully package and clearly mark all spare parts and accessories.

1.5 MAINTENANCE

1.5.1 Accessories and Tools

Furnish a complete set of accessories and special tools unique to equipment provided and required for erecting, handling, dismantling, testing and maintaining the apparatus.

1.5.2 Extra Materials

Furnish spare parts as specified below. All spare parts must be of the same material and workmanship, must meet the same requirements, and must be interchangeable with the corresponding original parts furnished.

SPARE PARTS	
Amount	Description
2 of each type and size	Fuses
1	Circuit breaker auxiliary switch
2 for each size ac contactor	Operating coils
1 for each size dc contactor	Operating coil

SPARE PARTS	
Amount	Description
2 Complete sets for each size ac contactor	3-pole stationary and moving contact assemblies
1 Complete set for each size dc contactor	2-pole stationary and moving contact assemblies
3 of each type and rating	Contactor overload relays, each relay with a complete set of contact blocks
1 Spare set for each heater rating provided	Heater elements
2 for each type	Indicating lamp assemblies
1 of each type and rating	Control transformer
1 of each type and rating	Control relay
1 of each type	Contactor auxiliary contact
1 for each type and rating	Circuit Breaker
1 for each type and rating	Motor Circuit Protector

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment which are standard products of a manufacturer regularly engaged in their manufacture and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening and that conform to the requirements of these specifications. Provide high quality materials, free from defects and imperfections, of recent manufacture, and of the classification and grades designated. All materials, supplies, and articles not manufactured by the Subcontractor must be the products of other recognized reputable manufacturers.

2.1.1 Rules

Provide equipment conforming to the requirements of NFPA 70 unless more stringent requirements are indicated herein or shown. NEMA rated and UL listed equipment has been specified when available. Provide equipment meeting NEMA and UL construction and rating requirements as specified. No equivalent will be acceptable. Immediately notify the Contractor/Buyer of any requirements of the specifications or Subcontractor proposed materials or assemblies that do not comply with UL or NEMA. International Electrotechnical Commission (IEC) rated equipment will not be considered an acceptable alternative to specified NEMA ratings.

2.1.2 Coordination

The general arrangement of the motor control centers, switchboards and panelboards is shown on the contract drawings. Any modifications of the equipment arrangement or device requirements as indicated will be subject to the approval of the Contractor/Buyer. If any conflicts occur necessitating departures from the drawings, submit details of and reasons for departures for approval prior to implementing any change. Completely assemble all equipment at the factory. The motor control centers and switchboards may be disassembled into sections, if necessary, for convenience of handling, shipping, and installation.

2.2 NAMEPLATES

Provide nameplates made of laminated sheet plastic or of anodized aluminum approximately 1/8-inch thick, engraved to provide white letters on a black background. Fasten the nameplates to the panels in proper positions with anodized round-head screws. Lettering must be minimum ½ inch high. Provide nameplate designations in accordance with lists on the drawings, and as a minimum provide nameplates for the following equipment:

a. Individual items of equipment mounted in the Motor Control Centers

b. Switchboards

[d. Individually-mounted circuit breakers in Switchboard]

[e. Group-mounted circuit breakers in Switchboard]

f. Panelboards

[g. Individually-mounted circuit breakers in Panelboard]

Provide equipment of the withdrawal type with nameplates mounted on the removable equipment in locations visible when the equipment is in place.

2.3 CONNECTIONS

Furnish all bolts, studs, machine screws, nuts, and tapped holes in accordance with ASME B1.1. Provide sizes and threads of all conduit and fittings, tubing and fittings, and connecting equipment in accordance with ASME B1.20.1. Provide ferrous fasteners that have rust-resistant finish and equip all bolts and screws with approved locking devices. Manufacturer's standard threads and construction may be used on small items which, in the opinion of the Contractor/Buyer, are integrally replaceable, except that threads for external connections to these items must meet the above requirements.

2.4 MOLDED CASE CIRCUIT BREAKERS

Provide molded case circuit breakers conforming to the applicable requirements of UL 489 and UL 489. Provide circuit breakers that are manually-operated, that are the quick-make, quick-break, common trip type, and that are of the automatic-trip type unless otherwise specified or indicated on the drawings. Operate all poles of each breaker simultaneously by means of a common handle. Provide operating handles that clearly indicate whether the breakers are in "On," "Off," or "Tripped" position and have provisions for padlocking in the "Off" position. Provide personnel safety line terminal shields for each breaker. Furnish circuit breakers that are products of only one manufacturer, and are interchangeable when of the same frame size. [Where indicated on the drawings, provide circuit breakers with shunt trip devices.] [Where indicated on the drawings, provide circuit breakers with bell alarm contacts that close on automatic operation only. Provide contacts that are suitable for [125] [_____] volts dc and reset when the breaker is reset.]

2.4.1 Trip Units

Except as otherwise noted, provide combination thermal and instantaneous magnetic or solid state trip units for the circuit breakers, of frame sizes and the trip unit ratings as shown on the drawings. The Contractor/Buyer reserves the right to change the indicated trip ratings, within frame limits, of the trip devices at the time the shop drawings are submitted for approval. Submit copies of outline drawings of all equipment to be furnished under this contract, together with weights and overall dimensions, within 30 calendar days after date of receipt of notice to proceed, for the approval of the Contractor/Buyer. Provide interchangeable breaker trip units and instantaneous magnetic trip units that are adjustable on frame sizes larger than 150 amperes. Set nonadjustable instantaneous magnetic trip units at approximately 10 times the continuous current ratings of the circuit breakers. [Solid state trip units, where indicated, must also have adjustable [long time pick-up and delay],[short time pick-up and delay], [and ground fault pick-up and delay].]

2.4.2 480-Volt AC Circuits

Furnish circuit breakers for 480-volt or 277/480-volt ac circuits that are rated 600 volts ac, and that have an UL listed minimum interrupting capacity of [14,000] [__________________________________] symmetrical amperes at [600] [______________________________________] volts ac.

2.4.3 120/240-Volt AC Circuits

Circuit breakers for 120-volt ac circuits rated less than 120/240 or 240 volts ac are not permitted, and must have a UL listed minimum interrupting capacity of [10,000] [_____] symmetrical amperes.

2.4.4 125-Volt DC Circuits

Circuit breakers for 125-volt dc circuits must be two-pole rated 125/250 or
250 volts dc, and must have an UL listed minimum interrupting capacity of [5,000] [10,000] [_____] amperes dc.

2.5 WIRING

Provide control wire consisting of stranded tinned copper switchboard wire with 600-volt flame-retardant insulation Type SIS meeting UL 44 or Type MTW meeting UL 1063, and passing the VW-1 flame tests included in those standards. Provide hinge wire consisting of Class K stranding. Current transformer secondary leads smaller than No. 10 AWG is not permitted. The minimum size of control wire is to be No. 14 AWG. Furnish power wiring for 480-volt circuits and below that is the same type as control wiring and a minimum size of No. 12 AWG. Give special attention to wiring and terminal arrangement on the terminal blocks to permit the individual conductors of each external cable to be terminated on adjacent terminal points.

2.6 CONTROL SWITCHES

2.6.1 General

All control switches must be of the rotary switchboard type with handles on the front and the operating contact mechanisms on the rear of the panels.

Provide each switch with ample contact stages to perform the functions of the control system and provide with at least two spare contacts. Provide self-aligning contacts that operate with a wiping action. Provide a positive means of maintaining high pressure on closed contacts. Compression springs or pivotal joints must not carry current. All control switches must be suitable for operation on 600-volt AC or 250-volt DC circuits. All such switches must be capable of satisfactorily withstanding a life test of at least 10,000 operations with rated current flowing in the switch contacts. Provide switches capable of continuously carrying 20 amperes without exceeding a temperature rise of 30 degrees C. The single-break inductive load interrupting rating of switches must not be less than 1.5 amperes for 125 volts DC or 10 amperes for 115 volts AC.

2.6.2 Switch Features

a. Provide control and instrument switches that are suitable for the intended use and that have the features shown on the schematic diagrams and switch development drawings. Provide switches that have handles as shown or approved and are black in color unless otherwise specified.

b. Control switches for electrically-operated circuit breakers must be 3-position momentary-contact type with spring return to neutral position, and must have modern-black, heavy duty pistol grip handles. Provide circuit breaker control switches that have mechanical operation indicators to show the last manual operation of the switches and slip contacts.

c. Provide control switches for instrument and meter transfer switches and for selector switches that are the maintained contact type with the required number of positions and that have round notched or knurled handles. Connect ammeter and voltmeter switches to read all three phase ammeter switches. Do not open the secondary circuits of the current transformer at any time.

c. Provide each control switch with an escutcheon clearly marked to show each operating position. Engrave the switch identifications on the escutcheon plates or on separate nameplates. The escutcheon and nameplate markings are subject to approval.

2.7 TERMINAL BLOCKS

Furnish control circuit terminal blocks for control wiring that are molded or fabricated type with barriers, rated not less than 600 volts. Provide terminals that are removable binding, fillister, or washer head screw type, or of the stud type with contact and locking nuts. The terminals must be no less than No. 10 in size and have sufficient length and space for connecting at least two indented terminals for 10 AWG conductors to each terminal. The terminal arrangement is subject to the approval of the Contractor/Buyer and provide no less than four (4) spare terminals or 10 percent, whichever is greater, on each block or group of blocks. Modular, pull apart, terminal blocks will be acceptable provided they are of the channel or rail-mounted type. Submit data showing that the proposed alternate will accommodate the specified number of wires, are of adequate current-carrying capacity, and are constructed to assure positive contact between current-carrying parts.

2.7.1 Types of Terminal Blocks

2.7.1.1 Short-Circuiting Type

Furnish short-circuiting type terminal blocks for all current transformer secondary leads and have provision for shorting together all leads from each current transformer without first opening any circuit. Provide terminal blocks meeting the requirements of paragraph CONTROL CIRCUIT TERMINAL BLOCKS above.

2.7.1.2 Load Type

Provide load terminal blocks rated no less than 600 volts and of adequate capacity for the conductors for NEMA Size 3 and smaller motor controllers and for other power circuits except those for feeder tap units. Provide terminals that are either the stud type with contact nuts and locking nuts or the removable screw type, having length and space for at least two indented terminals of the size required on the conductors to be terminated. For conductors rated more than 50 amperes, provide screws with hexagonal heads. Conducting parts between connected terminals must have adequate contact surface and cross-section to operate without overheating. Place the circuit designation or wire number on or near the terminal in permanent contrasting color for each connected terminal.

2.7.2 Marking Strips

Provide white or other light-colored plastic marking strips, fastened by screws to each terminal block, for wire designations. Make wire numbers with permanent ink. Use reversible marking strips to permit marking both sides, or furnish two marking strips with each block. Marking strips must accommodate the two sets of wire numbers. For each device to which a connection is made, assign a device designation in accordance with NEMA ICS 1 and mark each device terminal to which a connection is made with a distinct terminal marking corresponding to the wire designation used on the Subcontractor's schematic and connection diagrams. The wire (terminal point) designations used on the Subcontractor's wiring diagrams and printed on terminal block marking strips may be according to the Subcontractor's standard practice; however, provide additional wire and cable designations for identification of remote (external) circuits for the Contractor/Buyer's wire designations. Show the general arrangement and overall dimensions of the motor control centers, switchboards, and panelboards. Show space requirements, details of any floor supports to be embedded in concrete and provisions for conduits for external cables. Prints of drawings submitted for approval will be so marked and returned to the Subcontractor for addition of the designations to the terminal strips and tracings, along with any rearrangement of points required.

2.10 SWITCHBOARDS

Provide dead-front switchboards conforming to NEMA PB 2 and label under UL 891. Provide completely enclosed self-supporting metal structures with the required number of vertical panel sections, buses, molded-case circuit breakers, [and other devices] as shown on the drawings. Provide switchboards that are fully rated for a short-circuit current of [14,000] [22,000] [65,000] [_____] symmetrical amperes RMS AC.

2.10.1 Enclosure

Provide NEMA type [2] [3R] switchboard enclosure, built with selected smooth sheet steel panels of no less than No. 14 gage. Exposed panels on the front and ends must have bent angle or channel edges with all corner seams welded and ground smooth. Do not drill or weld the front outside surfaces for the purpose of attaching wires or mounting devices if such holes or fastenings will be visible from the front. Make the front panels in sections flanged on four sides and attach to the framework by screws and arrange for ready removal for inspection or maintenance. [Provide rear access to the bus and device connections.] Provide ventilating openings as required and preferably of the grille type. Provide all ventilating openings with corrosion-resistant insect-proof screens on the inside. [Provide each switchboard with a channel iron base at front, rear, and sides, with exposed ends covered by welded steel plates. Provide grout holes. Bolt the switchboard sections to the base.] [Mount switchboards as shown on the drawings and furnish mounting materials as indicated.] Treat all interior and exterior steel parts to inhibit corrosion and paint as specified in paragraph PAINTING.

2.10.2 Bus

Provide buses that are copper [or aluminum] and [all bolted splices and connections between buses and for extensions or taps for equipment] that are tin or silver-plated [throughout]. Provide copper [or aluminum] bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M [, and ASTM B317/B317M]. Bolt all splices for field assembly with at least two bolts and employ the use of "Belleville" washers in the connection. Horizontal and vertical power buses have minimum current ratings as shown on the drawings. Insulate the buses for no less than 600 volts. Braze, pressure-weld or bolt shop splices and tap connections. Bolt all splices for field assembly. Mount the buses on insulating supports of wet process porcelain, glass polyester, or suitable molded material, and brace to withstand no less than [14,000] [22,000] [65,000] [_____] symmetrical amperes ac.

2.10.3 Grounding Bus

Mount a copper [or aluminum] ground bus, rated no less than 300 amps, extending the entire length of the assembled structure, near the bottom of enclosure. Provide a full clamp-type solderless copper or copper alloy lug for No. 2/0 AWG stranded copper cable at each end of the bus for connection to the station grounding system.

2.10.4 Components

Equip each switchboard with molded-case circuit breakers conforming to paragraph MOLDED CASE CIRCUIT BREAKERS and with frame sizes, trip ratings, and terminal connectors for attachment of outgoing power cables as shown on the drawings. Stationary mount the circuit breakers individually, as shown on the drawings, that are operable and removable from the front. Where shown on the drawings, enclose circuit breakers in individual compartments. [Provide the group-mounted circuit breakers complete with bus work in an integrated assembly on the switchboard and conform to the applicable requirements of paragraph PANELBOARDS.]

2.11 PANELBOARDS

Provide panelboards consisting of assemblies of molded-case circuit breakers with buses and terminal lugs for the control and protection of branch circuits to motors, heating devices and other equipment operating at

480 volts ac or less. Provide UL 67 labeled panelboards. "Loadcenter" type panels are not acceptable. Design panelboards for installation in surface-mounted or flush-mounted cabinets accessible from the front only, as shown on the drawings. Provide panelboards that are fully rated for a short-circuit current of [14,000] [22,000] [___________] symmetrical amperes RMS ac.

2.11.1 Enclosure

Furnish enclosures meeting the requirements of UL 50. Fabricate all cabinets from sheet steel of no less than No 10 gage if flush-mounted or mounted outdoors, and no less than No 12 gage if surface-mounted indoors, with full seam-welded box ends. Hot-dip galvanize cabinets mounted outdoors or flush-mounted after fabrication. Paint cabinets in accordance with paragraph PAINTING. Provide outdoor cabinets of NEMA 3R raintight and [conduit hubs welded to the cabinet] [a removable steel plate ¼ inch thick in the bottom for field drilling for conduit connections.]
Form-flange edges of cabinets or fit with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. Fabricate all cabinets so that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch. Provide holes in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a ½-inch clear space between the back of the cabinet and the wall surface. Mount flush doors on hinges that expose only the hinge roll to view when the door is closed. Fit each door with a combined catch and lock, except provide doors over 24 inches long with a three-point latch having a knob with a T-handle, and a cylinder lock. Provide two keys with each lock, and key all locks alike. Provide finished-head cap screws for mounting the panelboard fronts on the cabinets. Provide enclosure nameplates in accordance with paragraph NAMEPLATES. Provide directory holders, containing a neatly typed or printed directory under a transparent cover, on the inside of panelboard doors.

2.11.2 Buses

Provide dead-front type panelboards with buses and circuit breakers mounted on a plate or base for installation as a unit in a cabinet. Provide buses that are copper [or aluminum] [and are tin or silver-plated throughout].

Provide copper [or aluminum] bars and shapes for bus conductors conforming to the applicable requirements of ASTM B187/B187M[, and ASTM B317/B317M]. Provide sizes of buses and the details of panelboard construction meeting or exceeding the requirements of NEMA PB 1. Make suitable provisions for mounting the bus within panelboards and adjusting their positions in the cabinets. Provide terminal lugs required to accommodate the conductor sizes shown on the drawing for all branch circuits larger than No. 10 AWG. Provide a grounding bus with a lug suitable for 1/0 AWG wire for each panelboard.

2.11.3 Components

Equip each branch circuit, and the main buses where so specified or shown on the drawings, with molded-case circuit breakers having overcurrent trip ratings as shown on the drawings. Provide circuit breakers designed for bolted connection to buses in a panelboard assembly, and meeting the requirements of paragraph MOLDED CASE CIRCUIT BREAKERS. Circuit breakers of the same frame size and rating must be interchangeable. [Furnish bell alarm contacts as indicated on the drawings and wire to terminal blocks mounted in the cabinet. Furnish terminal blocks conforming to requirements of paragraph TERMINAL BLOCKS.]

2.12 FACTORY TESTS

Each item of equipment supplied under this contract must be given the manufacturer's routine factory tests and tests as specified below, to ensure successful operation of all parts of the assemblies. The Contractor/Buyer will witness all tests required herein unless waived in writing, and no equipment will be shipped until it has been approved for shipment by the Contractor/Buyer.

a. Submit copies of manufacturer's routine factory test procedures and production line tests for all motor control centers and switchboards, within a minimum of 14 calendar days prior to the proposed date of tests. Notify the Contractor/Buyer a minimum of 14 calendar days prior to the proposed date of the tests so that arrangements can be made for the Contractor/Buyer to be present at the tests.

b. Use factory test equipment and the test methods conforming to the applicable NEMA Standards, and are subject to the approval of the Contractor/Buyer. Submit complete reproducible copies of the factory inspection results and complete reproducible copies of the factory test results in booklet form, including all plotted data curves, all test conditions, a listing of test equipment complete with calibration certifications, and all measurements taken.

c. Report must be signed and dated by the Subcontractor's and Contractor/Buyer's Representatives. Reports of all witnessed tests must be signed by witnessing representatives of the Subcontractor and Contractor/Buyer. The Subcontractor is responsible for the cost of performing all tests and include in the prices bid in the schedule for equipment.

2.12.1 Motor Control Centers Tests

2.12.1.1 Dielectric Tests

Completely assemble each motor control center and perform dielectric tests in accordance with NEMA ICS 1.

2.12.1.2 Operational Tests

Check the correctness of operation of each air circuit breaker [or motor circuit protector] and magnetic contactor and of all control devices, accessories and indicating lamps. Make these checks rated voltage with power supplies to the main buses. Also check all magnetic contactors for proper operation with power at 90 percent of rated voltage.

2.12.1.3 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Subcontractor may submit design tests demonstrating that satisfactory short-circuit tests, as specified in NEMA ICS 2, have been made on a motor control center of similar type of construction and having the same available short circuit current at the motor terminals, including any motor contributions, as the motor control centers specified to be furnished under these specifications.

2.12.2 Switchboards Tests

2.12.2.1 Production Tests

Completely assemble each switchboard and give applicable production tests for assembled switchboard as specified in NEMA PB 2.

2.12.2.2 Short Circuit Tests

If the unit is not UL labeled for the specified short circuit, the Subcontractor may submit design tests demonstrating that satisfactory short-circuit tests have been made on a switchboard of similar type of construction and of the same short-circuit rating as the switchboards specified to be furnished under these specifications.

2.12.3 Panelboards Tests

Assemble each panelboard with cabinet and front to the extent necessary to check the fit and provisions for installing all parts in the field. Give each panelboard a dielectric test in accordance with NEMA PB 1. Operate all circuit breakers to check mechanical adjustments. Check all doors and locks for door clearances and fits and the performance of lock and latches.

2.13 PAINTING

Clean interior and exterior steel surfaces of equipment enclosures thoroughly and then apply a rust-inhibitive phosphatizing or equivalent treatment prior to painting. Exterior surfaces must be free from holes, seams, dents, weld marks, loose scale or other imperfections. Apply no less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice to exterior surfaces. Prime exterior, fill where necessary, and give no less than two coats baked enamel with semigloss finish. Equipment located indoors must be ANSI Light Gray, [and equipment located outdoors must be ANSI [Light Grey] [Dark Gray].] Perform all touch-up work with manufacturer's coatings as supplied under paragraph SPARE PARTS.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding [25][_____] ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchboards

NEMA PB 1.

3.3.2 Panelboards

NEMA PB 2.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations

3.5.1.1 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

1. Compare nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Inspect arc chutes.

6. Inspect moving and stationary contacts for condition, wear, and alignment.

7. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

8. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify cell fit and element alignment.

11. Verify racking mechanism.

12. Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

1. Perform contact-resistance tests on each breaker.

2. Perform insulation-resistance tests.

3. Adjust Breaker(s) for final settings in accordance with Contractor/Buyer provided settings.

4. Determine long-time minimum pickup current by primary current injection.

5. Determine long-time delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Activate auxiliary protective devices, such as ground-fault or

undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

10. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

11. Verify operation of charging mechanism.

3.5.1.2 Current Transformers

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Verify correct connection.

4. Verify that adequate clearances exist between primary and secondary circuit.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform insulation-resistance tests.

3. Perform polarity tests.

4. Perform ratio-verification tests.

3.5.1.3 Grounding System

a. Visual and Mechanical Inspection

1. Inspect ground system for compliance with contract plans and specifications.

3.5.1.4 Switches, Air, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit studies, and coordination study.

7. Verify that each fuse has adequate mechanical support and contact integrity.

8. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

9. Verify operation and sequencing of interlocking systems.

10. Verify correct phase barrier installation.

11. Verify correct operation of all indicating and control devices.

12. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, in accordance with Section 7.5.1.1.A.8.1 of NETA ATS.

2. Measure contact resistance across each switchblade and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

4. Measure fuse resistance.

5. Verify cubicle space heater operation.

6. Perform ground fault test in accordance with Section 7.14 of NETA ATS.

7. Perform tests on other protective devices in accordance with Section 7.9 of NETA ATS.

3.5.1.5 Switches, Air, Medium-Voltage, Metal-Enclosed

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify the unit is clean.

5. Verify correct blade alignment, blade penetration, travel stops, arc interrupter operation, and mechanical operation.

6. Verify that fuse sizes and types are in accordance with drawings, short-circuit study, and coordination study.

7. Verify that expulsion-limiting devices are in place on all fuses having expulsion-type elements.

8. Verify that each fuseholder has adequate mechanical support and contact integrity.

9. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

10. Verify operation and sequencing of interlocking systems.

11. Verify correct phase barrier installation.

12. Verify correct operation of all indicating and control devices.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.5.1.2.A.9.1 of NETA ATS.

2. Measure contact resistance across each switchblade assembly and fuseholder.

3. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

4. Perform a dielectric withstand voltage test on each pole with switch closed. Test each pole-to-ground with all other poles grounded. Test voltage will be in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.2 of NETA ATS.

5. Measure fuse resistance.

6. Verify cubicle space heater operation.

7. Perform online partial-discharge survey in accordance with Section 11 of NETA ATS.

3.5.1.6 Circuit Breakers

3.5.1.6.1 Circuit Breakers, Air, Insulated-Case/Molded-Case

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage and alignment.

4. Verify the unit is clean.

5. Operate the circuit breaker to insure smooth operation.

6. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

7. Inspect operating mechanism, contacts, and arc chutes in unsealed nits.

8. Perform adjustments for final protective device settings in accordance with the coordination study.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.1.A.6.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and time delay by primary current injection.

8. Determine instantaneous pickup by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer’s published data.

11. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.6.2 Circuit Breakers, Low-Voltage Power

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

9. Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism in accordance with manufacturer's published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform adjustments for final protective device settings in accordance with coordination study provided by end user.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.1.2.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole,

phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

5. Determine long-time pickup and delay by primary current injection.

6. Determine short-time pickup and delay by primary current injection.

7. Determine ground-fault pickup and delay by primary current injection.

8. Determine instantaneous pickup value by primary current injection.

9. Test functions of the trip unit by means of secondary injection.

10. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

11. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

12. Verify operation of charging mechanism.

3.5.1.6.3 Circuit Breakers, Air, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Verify the arc chutes are intact.

7. Inspect moving and stationary contacts for condition and alignment.

8. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that

contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use IEEE C37.04.

9. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer’s published data.

10. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey

11. Verify cell fit and element alignment.

12. Verify racking mechanism operation.

13. Inspect puffer operation.

14. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Record as-found and as-left operation-counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. See Section 7.6.1.3.A.10.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.1 of NETA ATS.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be on minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow manufacturer’s recommendation.

5. With breaker in the test position, make the following tests:

(a) Trip and close breaker with the control switch.

(b) Trip breaker by operating each of its protective relays.

(c) Verify mechanism charge, trip-free, and anti-pump functions.

6. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

7. Perform power-factor or dissipation-factor tests with breaker in both the open and closed positions.

8. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/ capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

9. Perform a dielectric withstand voltage test on each phase with the circuit breaker closed and the poles not under test grounded. Apply voltage in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.19 of NETA ATS.

10. Measure blowout coil circuit resistance.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.6.4 Circuit Breakers, Oil, Medium- and High-Voltage

a. Visual and Mechanical Inspection

1. Visual and Mechanical Inspection

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and required clearances.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify correct oil level in all tanks and bushings.

6. Verify that breather vents are clear.

7. Verify the unit is clean.

8. Inspect hydraulic system and air compressor in accordance with manufacturer’s published data.

9. Test alarms and pressure-limit switches for pneumatic and hydraulic operators as recommended by the manufacturer.

10. Perform mechanical operation tests on the operating mechanism in accordance with manufacturer’s published data.

11. While performing internal inspection:

(a) Remove oil. Lower tanks or remove manhole covers as necessary. Inspect bottom of tank for broken parts and debris.

(b) Inspect lift rod and toggle assemblies, contacts, interrupters, bumpers, dashpots, bushing current transformers, tank liners, and gaskets.

(c) Verify that contact sequence is in accordance with manufacturer's published data. In the absence of manufacturer's data, use IEEE C37.04.

(d) Fill tank(s) with filtered oil.

12. Inspect bolted electrical connections for high resistance using one or more of the following methods:

(a) Use of low-resistance ohmmeter in accordance with Section 7.6.2.B.1 of NETA ATS.

(b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.12 of NETA ATS.

(c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

14. Verify racking mechanism operation.

15. Perform contact-timing test.

16. Perform mechanism-motion analysis.

17. Perform trip/close coil current signature analysis.

18. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

19. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.2.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit-breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform a static contact/pole resistance test.

4. Perform a dynamic contact/pole resistance test.

5. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

6. Remove a sample of insulating liquid in accordance with ASTM D923. Sample will be tested in accordance with the referenced standard.

(a) Dielectric breakdown voltage: ASTM D877

(b) Color: ASTM D1500

(c) Power factor: ASTM D924

(d) Interfacial tension: ASTM D971

(e) Visual condition: ASTM D1524

(f) Neutralization number (acidity): ASTM D974

(g) Water content: ASTM D1533

7. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.20 of NETA ATS.

8. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, anti-pump function.

9. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

10. Perform power-factor or dissipation-factor tests on each pole with breaker open and each phase with breaker closed. Determine tank loss index.

11. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.6.5 Circuit Breakers, Vacuum, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. Perform all mechanical operation tests on the operating mechanism in accordance with manufacturer's published data.

7. Measure critical distances such as contact gap as recommended by manufacturer.

8. Inspect bolted electrical connections for high resistance using one or more of the following methods:

    (a) Use of low-resistance ohmmeter in accordance with Section 7.6.3.B.1 of NETA ATS.

    (b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.12 of NETA ATS.

    (c) Perform thermographic survey in accordance with Section 9 of NETA ATS.

9. Verify cell fit and element alignment.

10. Verify racking mechanism operation.

11. Verify appropriate lubrication on moving, current-carrying parts and on moving and sliding surfaces.

12. Perform contact-timing test.

13. Perform trip/close coil current signature analysis.

14. Perform mechanism motion analysis.

15. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.3.A.8.1 of NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.1 of NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

4. Perform a contact/pole-resistance test.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer's published data. In the absence of manufacturer's data, use Table 100.20 of NETA ATS.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and anti-pump function.

7. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

10. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.

11. Perform vacuum bottle integrity (dielectric withstand voltage) test across each vacuum bottle with the breaker in the open position in strict accordance with manufacturer’s published data.

12. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.19 of NETA ATS.

13. Verify operation of heaters.

14. Test instrument transformers in accordance with Section 7.10 of NETA ATS.

3.5.1.6.6 Circuit Breakers, SF6

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, and grounding.

4. Verify that all maintenance devices such as special tools and gauges specified by the manufacturer are available for servicing and operating the breaker.

5. Verify the unit is clean.

6. When provisions are made for sampling, remove a sample of SF6 gas and test in accordance with Table 100.13 of NETA ATS. Do not break seal or distort “sealed-for-life” interrupters.

7. Inspect operating mechanism and/or hydraulic or pneumatic system and SF6 gas-insulated system in accordance with manufacturer’s published data.

8. Test for SF6 gas leaks in accordance with manufacturer’s published data.

9. Verify correct operation of alarms and pressure-limit switches for pneumatic, hydraulic, and SF6 gas pressure in accordance with manufacturer’s published data.

10. If recommended by manufacturer, slow close/open breaker and check for binding, friction, contact alignment, and penetration. Verify that contact sequence is in accordance with manufacturer’s published data. In the absence of manufacturer’s data, refer to IEEE C37.04.

11. Perform all mechanical operation tests on the operating mechanism in accordance with the manufacturer’s published data.

12. Inspect all bolted electrical connections for high resistance using one or more of the following methods:

   (a) Use of a low-resistance ohmmeter in accordance with Section 7.6.4.B.1 of NETA ATS.

   (b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.12 of NETA ATS.

   (c) Perform a thermographic survey in accordance with Section 9 of NETA ATS.

13. Verify the appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

14. Perform contact-timing test.

15. Perform trip/close coil signature analysis.

16. Perform mechanism motion analysis.

17. Record as-found and as-left operation counter readings.

b. Electrical Tests

1. Perform resistance measurements through all bolted connections with a low-resistance ohmmeter in accordance with Section 7.6.4.A.12.1 of NETA ATS.

2. Perform insulation-resistance tests in accordance with Table 100.1 of NETA ATS from each pole-to-ground with breaker closed and across open poles at each phase. For single-tank breakers, perform insulation resistance tests in accordance with Table 100.1 from pole-to-pole.

3. Perform a contact/pole-resistance test.

4. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components or for control devices that cannot tolerate the voltage, follow manufacturer’s recommendation.

5. Perform minimum pickup voltage tests on trip and close coils in accordance with manufacturer’s published data.

6. Verify correct operation of any auxiliary features such as electrical close and trip operation, trip-free, and anti-pump function. Reset all trip logs and indicators.

7. Trip circuit breaker by operation of each protective device.

8. Perform power-factor or dissipation-factor tests on each pole with the breaker open and on each phase with the breaker closed.

9. Perform power-factor or dissipation-factor tests on each bushing equipped with a power-factor/capacitance tap. In the absence of a power-factor/capacitance tap, perform hot-collar tests. These tests will be in accordance with the test equipment manufacturer’s published data.

10. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data.

11. Verify operation of heaters.

12. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

3.5.1.7 Motor Control, Motor Starters, Low-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.

2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Verify the unit is clean.
5. Inspect contactors.

   (a) Verify mechanical operation.

   (b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.

6. Motor-Running Protection

   (a) Verify overload element rating/motor protection settings are correct for application.

   (b) If motor-running protection is provided by fuses, verify correct fuse rating.

7. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

8. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.1.A.7.1 from NETA ATS.

2. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with starter closed, and across each open pole. Test voltage will be in accordance with manufacturer's published data or Table 100.1 from NETA ATS.

3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer's recommendation.

4. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use Section 7.9 from NETA ATS.

5. Test circuit breakers in accordance with Section 7.6.1.1 from NETA ATS.

6. Perform operational al tests by initiating control devices.

3.5.1.8 Motor Control, Motor Starters, Medium-Voltage

a. Visual and Mechanical Inspection

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Verify the unit is clean.
5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.
6. Test electrical and mechanical interlock systems for correct operation and sequencing.
7. Verify correct barrier and shutter installation and operation.
8. Exercise active components and confirm correct operation of indicating devices.
9. Inspect contactors.

    (a) Verify mechanical operation.

    (b) Verify contact gap, wipe, alignment, and pressure are in accordance with manufacturer’s published data.

10. Verify overload protection rating is correct for its application. Set adjustable or programmable devices according to the protective device coordination study.
11. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

b. Electrical Tests

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter in accordance with Section 7.16.1.2.A.5.1 from NETA ATS.
2. Perform insulation-resistance tests on contactor(s) for one minute, phase-to-ground and phase-to-phase with the contactor closed, and across each open contact. Test voltage will be in accordance with manufacturer’s published data, or Table 100.1 from NETA ATS.
3. Perform insulation-resistance tests on all control wiring with respect to ground. Applied potential will be 500 volts dc for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration will be one minute. For units with solid-state components, follow manufacturer’s recommendation.
4. Perform magnetron atmospheric condition (MAC) test on each vacuum interrupter.
5. Perform a dielectric withstand voltage test in accordance with manufacturer’s published data. In the absence of manufacturer’s data, use Table 100.9 from NETA ATS.

6. Perform vacuum bottle integrity test (dielectric withstand voltage) across each vacuum bottle with the contacts in the open position in strict accordance with manufacturer's published data.

7. Perform contact resistance tests.

8. Measure blowout coil circuit resistance.

9. Measure resistance of power fuses.

10. Energize contactor using an auxiliary source. Adjust armature to minimize operating vibration.

11. Test control power transformers in accordance with Section 7.1.B.8 from NETA ATS.

12. Test starting transformers, in accordance with Section 7.2.1 from NETA ATS.

13. Test starting reactors, in accordance with 7.20.3 from NETA ATS.

14. Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, test in accordance with Section 7.9 from NETA ATS.

15. Standard Commissioning Specifications for Electrical Power Equipment & Systems.

16. Verify operation of cubicle space heater.

17. Test instrument transformers in accordance with Section 7.10 from NETA ATS.

18. Test metering devices in accordance with Section 7.11 from NETA ATS.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contractor/Buyer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

SECTION 26 29 23: ADJUSTABLE SPEED DRIVE (ASD) SYSTEMS UNDER 600 VOLTS
02/20, CHG 1: 05/21

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN/CENELEC)

EN 61800-3	(2017) Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 519	(2022) Standard for Harmonic Control in Electrical Power Systems
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 61000-3-12	(2012) Electromagnetic Compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and </=75 A per phase

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 3.1	(2019) Guide for the Application, Handling, Storage, Installation and Maintenance of Medium-Voltage AC Contactors, Controllers and Control Centers
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA ICS 7	(2020) Adjustable-Speed Drives

NEMA ICS 7.2 (2015) Application Guide for AC Adjustable Speed Drive Systems

NEMA ICS 61800-2 (2005) Adjustable Speed Electrical Power Drive Systems Part 2: General Requirements - Rating Specifications for Low Voltage Adjustable Frequency A.C. Power Drive Systems

NEMA MG 1 (2021) Motors and Generators NATIONAL FIRE

PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023) National Electrical Code

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices UNDERWRITERS

LABORATORIES (UL)

UL 489 (2016; Rev 2019) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

UL 61800-5-1 (2016) Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy

1.2 SYSTEM DESCRIPTION

1.2.1 Performance Requirements

1.2.1.1 Electromagnetic Interference Suppression

Computing devices, as defined by 47 CFR 15 and EN 61800-3 rules and regulations, must be certified to comply with the requirements for class A computing devices and labeled.

1.2.1.2 Electromechanical and Electrical Components

Ensure electrical and electromechanical components of the Adjustable Speed Drive (ASD) do not cause electromagnetic interference to adjacent electrical or electromechanical equipment while in operation.

1.2.2 Electrical Requirements

1.2.2.1 Power Line Surge Protection

IEEE C62.41.1 and IEEE C62.41.2, IEEE 519, IEC 61000-3-12 Control panel must have surge protection, included within the panel to protect the unit from damaging transient voltage surges. Surge protective device must be mounted near the incoming power source and properly wired to all three phases and ground. Fuses must not be used for surge protection.

1.2.2.2 Sensor and Control Wiring Surge Protection

I/O functions as specified must be protected against surges induced on control and sensor wiring installed outdoors and as shown. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Schematic Diagrams; Interconnecting Diagrams; Installation

Drawings;

As-Built Drawings; SD-03 Product Data

Adjustable Speed Drives; Wires and Cables

Equipment Schedule SD-06 Test Reports

ASD Test

Performance Verification Tests Endurance Test

SD-07 Certificates

Testing Agency's Field Supervisor NETA Certificate;

SD-08 Manufacturer's Instructions Installation instructions

SD-09 Manufacturer's Field Reports

Standard Products

SD-10 Operation and Maintenance Data Adjustable Speed Drives, Data

Package 4

1.4 QUALITY ASSURANCE

1.4.1 Schematic Diagrams

Submit diagrams showing circuits and device elements for each replaceable module. Schematic diagrams of printed circuit boards are permitted to group functional assemblies as devices, provided that sufficient information is provided for government maintenance personnel to verify proper operation of the functional assemblies.

1.4.2 Interconnecting Diagrams

Show interconnections between equipment assemblies, and external interfaces, including power and signal conductors. Include for enclosures and external devices.

1.4.3 Installation Drawings

Show floor plan of each site, with ASD's and motors indicated. Indicate ventilation requirements, adequate clearances, and cable routes. Submit drawings for Contractor/Buyer approval prior to equipment construction or integration. Immediately record modifications to original drawings made during installation for inclusion into the as-built drawings.

1.4.4 Equipment Schedule

Provide schedule of equipment supplied. Schedule must provide a cross reference between manufacturer data and identifiers indicated in shop drawings. Schedule must include the total quantity of each item of equipment supplied and data indicating compatibility with motors being driven. For complete assemblies, such as ASD's, provide the serial numbers of each assembly, and a sub-schedule of components within the assembly. Provide recommended spare parts listing for each assembly or component.

1.4.5 Installation Instructions

Provide installation instructions issued by the manufacturer of the equipment, including notes and recommendations, prior to shipment to the site. Provide operation instructions prior to acceptance testing.

1.4.6 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.
b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5 DELIVERY AND STORAGE

Store delivered equipment to protect from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.6 WARRANTY

The complete system must be warranted by the manufacturer for a period of one year. Repair or replace any component failing to perform its function as specified and documented at no additional cost to the Contractor/Buyer. Items repaired or replaced must be warranted for an additional period of at least one year from the date that it becomes functional again, as specified in FAR 52.246-21 Warranty of Construction.

1.7 MAINTENANCE

1.7.1 Spare Parts

Manufacturers provide spare parts in accordance with recommended spare parts list.

1.8.2 Operation and Maintenance Data

Provide service and maintenance information including preventive maintenance, assembly, and disassembly procedures. Include electrical drawings from electrical general sections. Provide additional information necessary to provide complete operation, repair, and maintenance information, detailed to the smallest replaceable unit. Include copies of as-built submittals. Provide routine preventative maintenance instructions, and equipment required. Provide instructions on how to modify program settings, and modify the control program. Provide instructions on drive adjustment, trouble-shooting, and configuration. Provide instructions on process tuning and system calibration.

1.8.3 Maintenance Support

During the warranty period, provide on-site, on-call maintenance services by drive manufacturer's personnel on the following basis: The service must be on a per-call basis with 36 hour response. Subcontractor is responsible for the maintenance of all hardware and software of the system during the warranty period. Various personnel of different expertise must be sent on-site depending on the nature of the maintenance service required. Costs must include travel, local transportation, living expenses, and labor rates of the service personnel while responding to the service request. The provisions of this Section are not in lieu of, nor relieve the Subcontractor of, warranty responsibilities covered in this specification. Should the result of the service request be the uncovering of a system defect covered under the warranty provisions, all costs for the call, including the labor necessary to identify the defect, must be borne by the Subcontractor.

1.8.4 Technical Support

Provide the ASDs with manufacturer's technical telephone support in English, readily available during normal working hours.

PART 2 PRODUCTS

2.1 ADJUSTABLE SPEED DRIVES (ASD)

Provide adjustable speed drive to control the speed of induction motor(s). The ASD must include the following minimum functions, features and ratings.

a. Input circuit breaker per UL 489 with a minimum of 10,000 amps symmetrical interrupting capacity and door interlocked external operator.

b. A converter stage per UL 61800-5-1 must change fixed voltage, fixed frequency, ac line power to a fixed dc voltage. The converter must utilize a full wave bridge design incorporating diode rectifiers. Silicon Controlled Rectifiers (SCR) are not acceptable. The converter must be insensitive to three phase rotation of the ac line and must not cause displacement power factor of less than .95 lagging under any speed and load condition.

c. An inverter stage must change fixed dc voltage to variable frequency, variable ac voltage for application to a standard NEMA MG 1 Part 30 motor designed for use with adjustable frequency power supplies. Switch the inverter to produce a sine coded pulse width modulated (PWM) output waveform.

d. The ASD shall be capable of supplying 110 percent of rated full load current for one minute at maximum ambient temperature.

e. The ASD must be designed to operate from a [_____] volt, plus or minus 10 percent, three phase, 60 Hz supply, and control motors with a corresponding voltage rating.

f. Acceleration and deceleration time must be independently adjustable from one second to 60 seconds.

[Adjust decelerating time by[providing an external dynamic braking resistor designed to meet NEMA ICS 61800-2 to be capable of decelerating six times the motor inertia with no more than 150 percent of rated current with the motor at its base speed.][providing an ASD with a regenerative braking designed to return some of braking energy from the motor to the AC power distribution system.][providing each of several ASD used in a process with a common DC bus tie designed to share the regenerative energy between tied in parallel controls.]]Required deceleration time may be achieved using not only dynamic braking resistor but with other methods described in NEMA ICS 7.2-2015 paragraph 5.2.5.

g. Adjustable full-time current limiting must limit the current to a preset value which must not exceed 110 percent of the controller rated current. The current limiting action must maintain the V/Hz ratio constant so that variable torque can be maintained. Short time starting override must allow starting current to reach 175 percent of controller rated current to maximum starting torque.

h. The controllers must be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to one speed range), without low speed cogging. Over frequency protection must be included such that a failure in the controller electronic circuitry must not cause frequency to exceed 110 percent of the maximum controller output frequency selected.

i. Minimum and maximum output frequency must be adjustable over the following ranges: 1) Minimum frequency 3 Hz to 50 percent of maximum selected frequency; 2) Maximum frequency 40 Hz to 60 Hz.

j. The controller efficiency at any speed must not be less than 96 percent.

k. The controllers must be capable of being restarted into a motor coasting in the forward direction without tripping.

l. Protection of power semiconductor components must be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controllers to any of the following conditions must not result in component failure or the need for fuse replacement:

(1) Short circuit at controller output

(2) Ground fault at controller output

(3) Open circuit at controller output

(4) Input undervoltage

(5) Input overvoltage

(6) Loss of input phase

(7) AC line switching transients

(8) Instantaneous overload

(9) Sustained overload exceeding 115 percent of controller rated current

(10) Over temperature

(11) Phase reversal

m. Solid state motor overload protection must [be included such that current exceeding an adjustable threshold must activate a 60 second timing circuit. Should current remain above the threshold continuously for the timing period, the controller will automatically shut down.][have [sensor in each phase,][[Class 10] [Class 20] [Class 10/20 selectable] tripping characteristic selected to protect motor against voltage and current unbalance and single phasing,] [Class II ground-fault protection, with start and run delays to prevent nuisance trip on staring,] [analog communication module,][[NC] [NO] isolated overload alarm contact,] [external overload, reset push button].]

n. Include slip compensation circuit that will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA MG 1 Part 30 designed for use with adjustable frequency power supplies motors to within plus or minus 0.5 percent of maximum speed without the necessity of a tachometer generator.

o. The ASD must be factory set for manual restart after the first protective circuit trip for malfunction (overcurrent, undervoltage, overvoltage or overtemperature) or an interruption of power. The ASD must be capable of being set for automatic restart after a selected time delay. If the drive faults again within a specified time period (adjustable 0-60 seconds), a manual restart will be required.[Provide Bidirectional Autospeed Search capable of starting the ASD into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.]

p. The ASD must include external fault reset capability. All the necessary logic to accept an external fault reset contact must be included.

q. Provide critical speed lockout circuitry to prevent operating at frequencies with critical harmonics that cause resonant vibrations.

The ASD must have a minimum of three user selectable bandwidths.

r. Provide properly sized [NEMA][IEC] rated by-pass and isolation contactors to enable operation of motor in the event of ASD failure[and for safety transfers motor between power converter output and bypass circuit using a field-selectable automatic and manual bypass mode]. Install mechanical and electrical interlocks between the by-pass and isolation contactors. Provide a selector switch and transfer delay timer. Motor overload and short circuit protective features must remain in use during the bypass mode.

s. Each individual ASD must meet the following Total Harmonic Distortion (THD) requirements at the input terminals to the factory assembly of the ASD or at the load disconnecting means serving the ASD and filter assembly. These measurements should be taken with the drive set at 90 percent frequency (rpms) and the motor under a minimum of 50 percent demand.

(1) The Voltage THD should not exceed 2.0 percent THD.

(2) The Current THD should not exceed 15.0 percent THD.

(3) If the standard factory ASD does not meet or exceed these requirements the factory must install appropriate equipment (Harmonic Traps, Filters, different Drive technology, etc.) to mitigate the distortion to assure performance of the VFD is within the limits.

(4) These tests should be performed at the Manufacturers Laboratory facilities and submitted as part of the Product Data Submittals, in order to prevent the necessity of adding mitigation equipment in the field. If the requirements listed above are met, IEEE 519 will also be met.

t. t. Minimum Operating Conditions. Designed and constructed ASD's to operate within the following service conditions:

(1) Ambient Temperature Rating: 0 to 120 degrees F.

(2) Non-condensing relative humidity rating: less than 95 percent.

(3) Ambient rating: Not exceed 3,300 feet.

2.1.1 ASD for Industrial Application

Provide the following operator control and monitoring devices mounted on the front panel of the ASD:

a. Manual speed potentiometer.

b. Hand-Off-Auto (HOA) switch.

c. Power on light.

d. Drive run power light.

e. Local display[capable of including ASD status, frequency, motor RPM, phase current, fault diagnostic in descriptive text, and all programmed parameters].

2.2 ENCLOSURES

Provide equipment enclosures conforming to NEMA 250, NEMA ICS 7, and NEMA ICS 6, with a heater if located outdoors. An HMCP device shall provide the disconnecting means. The operating handle shall protrude through the door, but the disconnect shall not be mounted on the door. The handle shall indicate ON, OFF, and tripped conditions. The handle shall have provisions to accommodate a minimum of three padlocks in the OFF position. Interlocks shall prevent unauthorized opening or closing of the ASD door with the disconnect handle in the ON position. The door handle interlock should have provisions to be defeated by qualified maintenance personnel.

2.3 WIRES AND CABLES

All wires and cables must conform to NEMA 250, NEMA ICS 7, NFPA 70.

2.4 NAMEPLATES

Provide manufacturer's standard, permanent nameplates for internal areas of enclosures.

2.5 SOURCE QUALITY CONTROL

2.5.1 ASD Test Plan

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test plans.

2.5.2 ASD Test Report

To ensure quality, each ASD must be subject to a series of in-plant quality control inspections before approval for shipment from the manufacturer's facilities. Provide test reports.

PART 3 EXECUTION

3.1 INSTALLATION

Per NEMA ICS 3.1, install equipment in accordance with the approved manufacturer's printed installation drawings, instructions, wiring diagrams, and as indicated on project drawings and the approved shop drawings. A field representative of the drive manufacturer must supervise the installation of all equipment, and wiring.

3.2 GROUNDING

Per NEMA ICS 7.2, ASD must be solidly grounded to the main distribution.

3.3 FIELD QUALITY CONTROL

Specified products must be tested as a system for conformance to specification requirements prior to scheduling the acceptance tests. Conduct performance verification tests in the presence of Contractor/Buyer representative, observing and documenting complete compliance of the system to the specifications. Submit a signed copy of the test results, certifying proper system operation before scheduling tests.

3.3.1 ASD Test

A proposed test plan must be submitted to the Contractor/Buyer at least 28 calendar days prior to proposed testing for approval. The tests must conform to NEMA ICS 1, NEMA ICS 7, and all manufacturer's safety regulations. The Contractor/Buyer reserves the right to witness all tests and review any documentation. Inform the Contractor/Buyer at least 14 working days prior to the dates of testing. Perform the ASD test [with the assistance of a factory-authorized service representative][engaging a qualified testing agency's field supervisor currently certified by NETA to supervise on-site testing].

3.3.2 Performance Verification Tests

"Performance Verification Test" plan must provide the step by step procedure required to establish formal verification of the performance of the ASD. Compliance with the specification requirements must be verified by inspections, review of critical data, demonstrations, and tests. The Contractor/Buyer reserves the right to witness all tests, review data, and request other such additional inspections and repeat tests as necessary to ensure that the system and provided services conform to the stated requirements. Inform the Contractor/Buyer 14 calendar days prior to the date the test is to be conducted.

3.3.3 Endurance Test

Immediately upon completion of the performance verification test, the endurance test must commence. The system must be operated at varying rates for not less than 192 consecutive hours, at an average effectiveness level of 0.9998, to demonstrate proper functioning of the complete PCS. Continue the test on a day-to-day basis until performance standard is met. The Subcontractor is not allowed in the building during the endurance test. The system must respond as designed.

3.4 DEMONSTRATION

3.4.1 Training

Coordinate training requirements with the Contractor/Buyer. Provide video tapes, if available, of all training provided to the Contractor/Buyer for subsequent use in training new personnel. Provide all training aids, texts, and expendable support material for a self-sufficient presentation shall be provided, the amount of which to be determined by the Contractor/Buyer.

3.4.1.1 Engineering/Maintenance Personnel Training

Accomplish the training program as specified. Training must be conducted on site at a location designated by the Contractor/Buyer. Provide a training session to train four [] engineering personnel in the functional operations of the system. This training must include:

a. System overview

b. General theory of operation

c. System operation

d. System configuration

e. Alarm formats

f. Failure recovery procedures

g. Troubleshooting and repair

h. Maintenance and calibration

i. System programming and configuration

-- End of Section --

SECTION 27 21 10.00 40: FIBER OPTIC DATA TRANSMISSION SYSTEM

11/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and Associated Equipment

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

ANSI/TIA-455-80C (2003) FOTP-80 - IEC 60793-1-144 Optical fibres Part 1-44: Measurement Methods and Test Procedures - Cut-off Wavelength

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2023) National Electrical Safety Code

IEEE C62.41.1 (2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.41.2 (2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232 (1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange

TIA-455-13 (1996a; R 2012) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies

TIA-455-58 (2001b) FOTP-58 Core Diameter Measurement of Graded-Index Optical Fibers

TIA-455-78-B	(2020c) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-82	(2020c) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
TIA-455-91	(1986; R 1996) FOTP-91 Fiber Optic Cable Twist-Bend Test
TIA-455-104	(2016b) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test
TIA-455-177	(2020c) FOTP-177 IEC-60793-1-43: Measurement Methods and Test Procedures - Numerical Aperture
TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA/EIA-455-25	(2016d) FOTP-25 Impact Testing of Optical Fiber Cables
TIA/EIA-455-41	(1993a; R 2013) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
TIA/EIA-455-81	(2000b) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
TIA/EIA-455-88	(2001) FOTP-88 Fiber Optic Cable Bend Test
TIA/EIA-455-171	(2001a) FOTP-171 - Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15	Radio Frequency Devices UNDERWRITERS

LABORATORIES (UL)

UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Test Procedures and Reports Power Attenuation Test Analog Video

Signal Test Digital Video Signal Test

Optical Time Domain Reflectometer Tests

SD-07 Certificates

Labeling Format

SD-08 Manufacturer's Instructions Manufacturer's Instructions

Manufacturer's Recommendations

SD-10 Operation and Maintenance Data Operating Instructions

1.3 MAINTENANCE MATERIAL SUBMITTALS

PART 2 PRODUCTS

2.1.1 Environmental Requirements

Rate equipment and cables for continuous outdoor operation under ambient environmental conditions of [minus 40] [minus [____]] to plus [166] [________________________] and humidity of up to 100 percent condensing or as normally encountered for the installed location. Rate all equipment and cable for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Install cables in ducts, plenums, and other air-handling spaces per NFPA 70. Ensure cables installed in plenums are plenum-rated cables listed for the use. Ensure cables installed in risers are riser-rated cables listed for the use unless the installed cable is identified as a permitted substitution for the required riser-rated cable type.

2.1.2 Hazardous Environment

Rate the system components and wiring located in areas where fire or explosion hazards may exist with the proper Classes, Divisions, and Groups. Also rate the components and wiring for the operating temperatures.
Install according to Chapter 5 of NFPA 70 and as shown.

2.1.3 Electrical Requirements

Operate the equipment from a voltage source as shown, plus or minus 10 percent, and 60 Hz, plus or minus 2 percent.

2.1.4 Input Line Surge Protection

Protect inputs and outputs against surges induced on wiring and cables including wiring and cables installed outdoors. For components requiring protection, select surge protection devices based on voltages and current ratings of components to be protected. Protect communications equipment against surges induced on any communications circuit. Install surge protection circuits at each end of cables and conductors (except non-conductive FO cables which serve as communications circuits from consoles to field equipment and between field equipment). Furnish protection at equipment. Install additional triple electrode gas surge protectors rated for the application on each conductive wire line and coaxial circuit within 3-feet of the building cable entrance. Do not use fuses for surge protection. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

2.1.5 Power Line Surge Protection

Protect equipment connected to AC circuits from power line surges. Select surge protection devices based on voltages and current ratings of components to be protected. Provide equipment that meets the requirements of IEEE C62.41.1 and IEEE C62.41.2. Do not use fuses for surge protection.

2.2 COMPONENTS

2.2.1 FO Modems

Select FO modems to meet FO system requirements. Ensure the modems allow full duplex, asynchronous, point-to-point digital communication for the system being installed.

2.2.1.1 FO Modem Operating Wavelength

Center the operating wavelength on [850] [1300] [1550] nanometers (nm).

2.2.1.2 FO Modem Inputs and Outputs

Provide FO modems that accept inputs and provide outputs compatible with [TIA-232] [TIA-485] [20 mA current loop] [T1] [10 Base-F]. Digital data rates through each link are [9.6 KBPS] [19.2 KBPS] [38.4 KBPS] [1.54 MBPS] [10 MBPS].

2.2.2 FO Transmitter And Receiver Modules

Ensure FO transmitter/receiver pairs have signal-to-noise power ratio of 40 dB or better after photo detection at the receiver. Transmitter power output and receiver sensitivity cannot drift more than plus or minus 2 dB over their operational life.

2.2.2.1 Analog FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass analog video signals accept inputs and provide outputs that have a bandwidth of 6 MHz or greater.

2.2.2.2 Digital FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass digital signals accept inputs and provide outputs compatible with [TIA-232] [TIA-485] [20 mA current loop] [T1] [10 Base-F]. Digital data rates through each link are [9.6 KBPS] [19.2 KBPS] [38.4 KBPS] [1.54 MBPS] [10 MBPS]. House FO transmitter and receiver modules [in field equipment enclosures where possible] [in new enclosures] [as shown]. Provide FO transmitter and receiver modules compatible with each other, the FO cable, and connectors.

2.2.2.3 FO Transmitter Module

Provide a FO transmitter module that accepts electronic signals and modulates a light source. Couple the light source into an FO cable. Center the operating wavelength on [850] [1300] [1550] [850 and 1300] [1300 and 1550] nanometers.

2.2.2.4 FO Receiver Module

Ensure the FO receiver module receives light from the FO cable and converts this light into an electronic signal identical to the electronic signal applied to the FO transmitter module. Ensure the operating wavelength is the same as the transmitter.

2.2.3 FO Digital Repeaters

Use FO digital repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For Duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receive the optical signal and drive the transmitters. The transmitters regenerate the optical signal at the transmission rate specified. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.4 FO Analog Repeaters

Use FO analog repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receives the optical signal and drive the transmitters. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.5 Transceivers for Lan Applications

Provide transceivers for FO LAN applications that are active units, and compatible with the LAN cards, modems and repeaters used in the system. Provide indicators for power, collision detection, receive, transmit, and status. Derive power for transceivers from the Attachment Unit Interface (AUI) port of LAN equipment or from a dedicated power supply. Ensure transceiver loss characteristics are less than 1.0 db. Provide low loss connectors that are compatible with LAN equipment. Include circuitry so when a device is disconnected, other devices on the LAN continue to operate without any disruption.

2.2.6 FO Switches

Provide single pole, double throw FO switches with switching speed less than 15 milliseconds, and insertion loss less than 1.5 dB. Provide crosstalk attenuation between FO outputs at 40 dB or greater. FO switches are latching or non-latching, as shown.

2.2.7 FO Splitter/Combiner

For FO splitter/combiner units, provide full-duplex communications in a multi-point configuration. Ensure each unit has one input port module and up to four output port modules. Ensure FO splitter/combiner units are mechanically and optically compatible with the remainder of the FO system. The splitter/combiner allows a mixed configuration of port module operating wavelengths and single-mode or multimode FO cables. Ensure each port module has a separate FO cable input and output. Connect port modules using an electronic data bus. Port module FO transmitters regenerate the optical signal at the transmission rate specified. Rack mount port modules in a 19-inch rack complying with ECIA EIA/ECA 310-E. Ensure the total propagation delay through the splitter/combiner is less than 100 nanoseconds.

2.2.8 Fiber Optic Digital Repeaters (FODR)

FODRs combine the features specified for Fiber Optic Digital Repeaters and Local Area Network (LAN) transceivers. FODRs regenerate the optical signal at the transmission rate specified. Ensure the FODRs are mechanically and optically compatible with the remainder of the Fiber Optic System. Ensure FODRs restore the optical signals amplitude, timing and waveform and provide an electrical interface to the transmission media. Ensure the electrical interface is identical to all other network interfaces as specified.

Submit a manufacturer's certificate of the Fiber Optic System indicating compliance with transmission and reliability requirements. Where equipment or materials are specified to conform to the standards or publications and requirements of CFR, ANSI, IEEE, NEMA, NFPA, EIA, or UL, furnish certificates attesting that the items identified conform to the specified requirements.

2.2.9 Data Transmission Converter

Use data transmission converters to connect equipment using TIA-485 data transmission when necessary and as shown. Install converters that operate full duplex and support two wire circuits at speeds up to 2 megabytes per second and have a built in 120 Ohm terminating resistor. Ensure converters are mechanically, electrically, and optically compatible with the system.

2.2.10 Enclosures

Ensure enclosures conform to the requirements of NEMA 250 for the types specified. Use the manufacturer's standard finish color, unless otherwise indicated. Repair and refinish damaged surfaces using original type finish.

2.2.10.1 Exterior

Ensure enclosures installed outdoors meet the requirements of NEMA 250 Type 4 unless otherwise specified or shown.

2.2.10.2 Corrosive Environment

For enclosures in a corrosive environment, meet the requirements of NEMA

250, Type 4X.

2.2.11 Tamper and Physical Protection Provisions

Provide enclosures and fittings of every description having hinged doors or removable covers that contain the FO circuits, connections, splices, or power supplies, with cover-operated, corrosion-resistant tamper switches, arranged to initiate an alarm signal when the door or cover is moved. Mechanically mount tamper switches to maximize the defeat time when enclosure covers are opened or removed. Ensure the enclosure and the tamper switch function together to not allow direct line of sight to any internal components and tampering with the switch or the circuits before the switch activates.

Ensure tamper switches are inaccessible until the switch is activated; have mounting hardware concealed so that the location of the switch cannot be observed from the exterior of the enclosure; are connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating; are spring-loaded and held in the closed position by the door cover; and are wired so that they break the circuit when the door or cover is disturbed.

Ensure tamper switches located in enclosures which open to make routine maintenance adjustments to the system and to service the power supplies are push/pull-set, automatic reset type.

2.2.11.1 Enclosure Covers

Covers of pull and junction boxes provided to facilitate installation of the system need not be provided with tamper switches if they contain no splices, connections or power supplies, but are protected by [security screws] [tack welding or brazing] to hold the covers in place. Affix zinc labels to such boxes indicating they contain no connections. Do not indicate with these labels that the box is part of a security system. Clean and repair damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure the conduit enclosures constructed of fiberglass with tamper proof security servers.

2.2.11.2 Conduit-Enclosure Connections

Protect conduit enclosure connections by tack welding or brazing the conduit to the enclosure. Apply tack welding or brazing in addition to standard conduit-enclosure connection methods as described in NFPA 70. Clean and repair any damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure conduit enclosures constructed of fiberglass with tamper proof security screws.

2.2.11.3 Locks and Key-Lock-Operated Switches

2.2.12 Optical Fibers

2.2.12.1 General

Coat optical fibers with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber is nominally 125 microns, and concentric with the fiber core. Ensure optical fibers meet TIA-455-78-B, and TIA-455-177.

2.2.12.2 50 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 50 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.20. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. For both transmission windows, the minimum bandwidth is 500 MHz-Km. Certify the fibers to meet TIA/EIA-455-204 and TIA-455-58.

2.2.12.3 62.5 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.275. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. The minimum bandwidth is 160 MHz-Km at 850 nanometers and 500 MHz-Km at 1300 nanometers. Certify FO cable to meet TIA/EIA-455-204 and TIA-455-58.

2.2.12.4 8.3 Micron Single-Mode Fibers

Use conductors that are single-mode, solid glass waveguides with a nominal core diameter of 8.3 microns. Ensure the fiber has a transmission windows centered at 1310 and 1550 nanometer wavelengths with a numerical aperture minimum of 0.10. The attenuation for inside cable at 1310 and 1550 nanometers is 1.0 dB/Km or less. The attenuation for outside cable at 1310 and 1550 nanometers is 0.5 dB/Km or less. Certify the fibers to meet ANSI/TIA-455-80C.

2.2.13 Cross-Connects

2.2.13.1 Patch Panels

Install patch panels as a complete system of components by a single manufacturer; provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Ensure patch panel connectors and couplers are the same type and configuration as used elsewhere in the system. Patch panels are [a 19-inch rack mount type] [wall mounted] [as shown].

2.2.13.2 Patch Cords

Provide patch cord cable assemblies consisting of factory connector-terminated flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber is the same type as used elsewhere in the system. Install patch cords as complete assemblies from manufacturer's standard products.

2.3 SYSTEM REQUIREMENTS

2.3.1 Signal Transmission Code Format

Ensure FO equipment uses the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

2.3.2 Flux Budget/Gain Margin

Provide FO links with a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. Ensure the flux budget is equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

2.3.3 Receiver Dynamic Range

Ensure the dynamic range of receivers is large enough to accommodate both the worst-case, minimum receiver flux density, and the maximum possible receiver flux density, with a range of at least 15 dB. Where required, use optical attenuators to force the FO link power to fall within the receiver dynamic range.

2.4 ACCESSORIES

2.4.1 FO Connectors

Use field installable, self-aligning and centering FO connectors. Match FO connectors with the fiber core and cladding diameters. Provide FO cable connectors at field equipment [of the type to match the field equipment connectors] [of type [_____]] [as shown]. Provide FO connectors at terminal head end equipment [of the type to match terminal head equipment connectors] [of type [_____]] [as shown]. Connector insertion loss is nominally 0.3 dB and maximum loss less than 0.7 dB.

2.4.2 Mechanical Splices

Mechanical splices are suitable for installation in the field. External power sources are not required to complete a mechanical splice. Use self-aligning mechanical splices for optimum signal coupling. Do not use mechanical splices for exterior applications where they may be buried underground or laced to aerial messenger cables. Mechanical splices may be used for interior locations and within enclosures. Protect the spliced fibers from moisture and prevent physical damage with splice closures. Use the splice closure to provide strain relief for the cable and the fibers at the splice points.

2.4.3 Fusion Splices

Use a portable, fully automatic, and compact fusion splicer, suitable for fusion splicing all types of telecommunication grade optical fibers and individual fibers as well as cables containing multiple optical fibers. Ensure the fusion splicer is capable of operation under various environmental conditions (e.g., temperature, humidity, altitude, etc.) for all types of optical cable deployments. Start the automatic splicing process by pressing one button and can be interrupted at any time. Alternatively, make available semi-automatic (step-by-step) or manual splicing by menu selection. Conduct communication with the fusion splicer through a language unspecific keyboard with universal symbols and display the dialogue with the splicer on the device screen.

2.4.4 Conduit, Fittings And Enclosures

Ensure conduit, fittings, and enclosures are as specified as shown.

2.4.5 Fan-Out Kits

For all loose-tube optical fibers, furnish and install fan-out kits using furcating tubes for connectorization. Incorporate strain relief for loose-tube optical fiber furcating tubes if the connectorization is not contained within a protective enclosure such as a patch panel. For tight-buffered optical fibers, furnish and install fan-out kits using furcating tubes and which incorporate strain relief, if the connectorization is not contained within a protective enclosure such as a patch panel. Furcating tubes required to incorporate strain relief also provide increased pullout protection. Tubes are comprised of an inner tube, surrounded by a layer of nonconductive strength members, then surrounded by an enclosing outer jacket layer. [Color code fan-out kits to match the industry fiber color scheme.] Length of furcating tube is [24] [36]-inches minimum when installation is complete. Rate fan-out kits for the ambient conditions of the location as specified in paragraph ENVIRONMENTAL REQUIREMENTS. Provide terminations for each fiber, regardless whether fiber is active or spare.

2.5 CABLE CONSTRUCTION

2.5.1 General

Ensure the cable contains a minimum of two FO fibers for each link circuit. The number of fibers in each cable is [______] [as shown]. Protect each fiber by a protective tube. Ensure cables have a jacketed strength member, and an exterior jacket. Ensure cable and fiber protective covering are free from holes, splits, blisters, and other imperfections. Insulation and jacketing material for interior cables cannot contain any polyvinyl chloride (PVC) compounds. Use a covering that is flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified, and nontoxic. Do not transmit mechanical stress present in cable to the optical fibers. Ensure strength members are non-metallic and an integral part of the cable construction. Ensure the combined strength of all the strength members is sufficient to support the stress of installation and to protect the cable in service. For exterior cables, select a minimum storage temperature range of minus 104 to plus 167 degrees F. A minimum storage temperature of plus 14 to plus 167 degrees F is required for interior cables. Ensure all optical fiber cables and all optical fiber raceways furnished meet the requirement of NFPA 70. Apply a flooding compound into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Ensure flooded cables comply with TIA/EIA-455-81 and TIA-455-82. Provide cables from the same manufacturer, of the same cable type, of the same size, and of the same optical characteristics. Ensure each fiber and protective coverings is continuous with no factory splices. Certify by the manufacturer, optic cable assemblies, including jacketing and fibers, to have a minimum life of
30 years. Ensure cables meet UL 1666. Certify FO cable to meet the

following: TIA-455-13, TIA/EIA-455-25, TIA/EIA-455-41, TIA-455-177, TIA-455-78-B, TIA/EIA-455-88, TIA-455-91, TIA-455-104, and TIA/EIA-455-171.

2.5.2 Exterior Cable

2.5.2.1 Duct Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material with orange pigment added for ease of identification.

b. Tensile strength: Withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 1.7 lbs/in as a minimum, and have a crush resistance of 317 psi as a minimum.

2.5.3 Pigtail Cables

Use flexible fiber pigtail cables for connections to equipment having the same physical and operational characteristics as the parent cable. Ensure the cable jacket is FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable is 3.5 dB/km at 850 nanometers, and 1.0 dB/km at 1300 nanometers, and [_____] dB/Km at 1550 nanometers.

PART 3 EXECUTION

3.1 INSTALLATION

Install system components and appurtenances in accordance with the manufacturer's instructions and as shown. Provide interconnections, services, and adjustments required for a complete and operable data transmission system.

Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations of the material being installed, submit printed copies of these recommendations prior to installation. Installation of the item is not allowed to proceed until the recommendations are received and approved.

3.1.1 Interior Work

Install conduits, tubing and cable trays for interior FO cable as shown. Ensure cable installation and applications meet the requirements of NFPA 70, Article 770. Properly support and secure cables not installed in conduits or wireways. If installed in plenums or other spaces used for environmental air, comply with NFPA 70 requirements for this type of installation.

3.1.2 Exterior Work Underground

Except as otherwise specified, install conduits, ducts, and manholes for underground FO cable systems as specified as shown.

a. Minimum burial depth for cable is 24 inches. Burial depth specified takes precedence over any requirements specified elsewhere.

b. Where direct burial cable passes under sidewalks, roads, or other paved areas, place the cable in a 1-inch zinc-coated rigid conduit or larger as required to limit conduit fill to 80 percent or less.

c. Place buried cables below a plastic warning tape buried in the same trench or slot. Place the warning tape 12 inches above the cable. Continuously imprint the warning tape with the words "WARNING - COMMUNICATIONS CABLE BELOW" at not more than 48-inch intervals. Use warning tape that is acid and alkali resistant polyethylene film, 3 inches wide with a minimum thickness of 0.004-inch, with a minimum strength of 1750 psi lengthwise and 1500 psi crosswise.

d. Transitions from underground cable to aerial cable are as shown.

e. For cables installed in ducts and conduit, use a cable lubricant compatible with the cable sheathing material on all cables pulled. Attach pulling fixtures to the cable strength members. If indirect attachments are used, match the grip diameter and length to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, reduce the pulling forces to ensure that the fibers are not damaged from forces being transmitted to the strength member. During pulling, continuously monitor the cable pull line tension using dynamometers or load-cell instruments. Do not exceed the maximum tension specified by the cable manufacturer. Ensure the mechanical stress placed upon the cable during installation is such that the cable is not twisted or stretched. Use a cable feeder guide between the cable reel and the face of the duct or conduit to protect the cable and guide it into the duct or conduit as it is un-spooled from the reel. As the cable is un-spooled from the reel, inspect it for jacket defects or damage. Do not kink or crush the cable. Do not exceed the minimum bend radius of the cable during installation. Hand feed and guide cable through each manhole and apply additional lubricant at all intermediate manholes. When practicable, use the center pulling technique to lower pulling tension. That is, pull the cable from the center point of the cable run towards the end termination points. The method may require the cable to be pulled in successive pulls. If the cable is pulled out of a junction box or manhole, protect the cable from dirt and moisture by laying the cable on a ground covering.

3.1.3 Service Loops

Ensure each FO cable has service loops of not less than 9.8-feet in length at each end. House the service loops in a service loop enclosure.

3.1.4 Metallic Sheath Grounding

Ground the FO cable with metallic sheath that enter buildings at a point as close as practicable to the building point of entrance. Ensure FO cable with metallic sheath routed in the trench with a power cable has the metallic sheath grounded at the cable termination points.

3.1.5 Splices

3.1.5.1 General

No splices are permitted unless the length of cable being installed exceeds the maximum standard cable length available from a manufacturer or unless FO pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber. Make splices using the method recommended by the cable manufacturer. Place splices in a splice enclosure and encapsulate with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants.
Field test FO splices at the time of splicing. Ensure fusion splices have a nominal splice loss of [0.15] [_____] dB for multimode and for single mode cable fusion splices and a maximum fusion splice loss not more than 0.3 dB loss.

3.1.5.2 Mechanical Splices

Install mechanical splices with a nominal splice loss of [0.15] [_____] dB for multimode fiber mechanical splices and [0.2] [_____] dB for single mode fiber mechanical splices with a maximum mechanical splice loss not more than [0.3] [_______________________________________] dB loss for multimode and single mode fiber mechanical splices. Install no more than 1 splice per 0.62 mile in any of the FO cables excluding terminations. Locate field splices in cable boxes.
Provide sufficient cable in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Protect cable ends with end caps except during actual splicing. During the splicing operations, provide means to protect the unspliced portions of the cable and its fibers from the intrusion of moisture and other foreign matter.

3.1.6 Connectors

Prior to and during installation of connectors, perform appropriate cleaning to ensure that any contaminant particulates larger than 0.06 micron in size are removed. Connectors are as specified in paragraph FO CONNECTORS. Connectors or splices which leave residue on the connector ferrule or optical connector "lens", are not permitted. Ensure fibers at each end of the cable have jumpers or pigtails installed of not less than 3 feet in length. For fibers at both ends of the cable, have connectors installed on the jumpers. Ensure the mated connector pair loss does not exceed [0.7] [_____] dB. The pull strength between the connector and the attached fiber cannot be less than 50 pounds.

3.1.7 Identification and Labeling

Provide identification tags or labels for each cable. For markers, tags and labels, use indelible ink or etching which does not fade in sunlight, or in buried or underground applications. Use markers, tags, and labels that do not become brittle or deteriorate for a period of 20 years due to moisture, sunlight, soil minerals, chemicals or other environmental elements. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with TIA-606 and as specified on drawings. Identify the labeling format and provide a complete record to the Contractor/Buyer with the final documentation. Identify each cable with type of signal being carried and termination points.

3.1.8 Enclosure Sizing and Cable

Size termination enclosures to accommodate the FO equipment to be installed. Sizing includes sufficient space for service loops to be provided and to accommodate a neat layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

3.1.9 Enclosure Penetrations

Install enclosure penetrations from the bottom. Seal penetrations with rubber silicone sealant to preclude the entry of water. Internally seal conduits rising from underground.

3.2 FIELD QUALITY CONTROL

3.2.1 General

Provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

3.2.2 Field Test

Verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system as specified in Section [_____] prior to formal acceptance testing. Include a flux density test in field tests. Perform these tests on each link and repeated from the opposite end of each link.

3.2.2.1 Optical Time Domain Reflectometer Tests

Perform optical time domain reflectometer tests using the FO test procedures of TIA-455-78-B. Perform an optical time domain reflectometer test on all fibers of the FO cable on the reel prior to installation. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. Furnish photographs of the traces to the Contractor/Buyer. Perform an optical time domain reflectometer test on all fibers of the FO cable after it is installed. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. If the optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable to the Contractor/Buyer. Replace the unsatisfactory segments of cable with a new segment of cable. Then test the new segment of cable to demonstrate acceptability. Furnish photographs of the traces to the Contractor/Buyer for each link.

3.2.2.2 Power Attenuation Test

Perform power attenuation test at each light wavelength of the transmitter to be used on the circuit being tested. Measure the flux at the FO receiver end and compare to the flux injected at the transmitter end. Add a jumper at each end of the circuit under test so that end connector loss is validated. Rotational optimization of the connectors is not permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory. Examine the circuit to determine the problem. Notify the Contractor/Buyer of the problem and propose procedures to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.3 Gain Margin Test

Test and verify that each circuit has a gain margin which exceeds the circuit loss by at least the minimum gain margin specified in paragraph FLUX BUDGET/GAIN MARGIN.

3.2.2.4 Analog Video Signal Test

Test analog video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Contractor/Buyer of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.5 Digital Video Signal Test

Test digital video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Contractor/Buyer of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.6 Performance Verification Test and Endurance Test

Test the FO data transmission system as a part of the completed [UMCS] [IDS] [ESS] [CCTV] [_____] during the Performance Verification Test and Endurance Test.

3.3 CLOSEOUT ACTIVITIES

3.3.1.1.1 Operation and Maintenance Data

Deliver a draft copy of the operation and maintenance data.

3.3.1.1.2 Maintenance Manual

Include the maintenance descriptions for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

3.3.1.1.3 Operator's Manual

Ensure the operator's manual fully explains procedures and instructions for operation of the system. This includes an operator's manual for any FO systems in which system operators control any function of the system.

3.3.2 Training

Conduct a training course for designated personnel in the maintenance of the FO system. Orient the training to the specific system being installed under this specification. Furnish all training materials and supplies.

3.3.2.1 System Maintenance Training Course

Provide two copies of operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions includes the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Provide two copies of the maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed. A video describing operating and maintenance instructions may be included.

Provide a system maintenance course taught at the project site after completion of the endurance test for a period of 1 training day. A maximum of five personnel designated by the Contractor/Buyer will attend the course. A training day consists of 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunchtime during the daytime shift in effect at the facility. Training includes:

a. Physical layout of the system and each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Repair instructions.

d. Preventative maintenance procedures and schedules.

e. Calibration procedures.

-- End of Section --

SECTION 31 00 00: EARTHWORK

08/23

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop AMERICAN WATER WORKS

ASSOCIATION (AWWA)

AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020; Errata 1 2021) Structural Welding Code - Steel

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C260/C260M	(2010a; R 2016) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C618	(2023; E 2023) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989/C989M	(2022) Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2321	(2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2974	(2020; E 2020) Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
ASTM D4253	(2016; E 2019) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4829	(2021) Standard Test Method for Expansion Index of Soils
ASTM D4832	(2016; E 2018) Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D5268	(2019) Topsoil Used for Landscaping Purposes
ASTM D6023	(2016) Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)

ASTM D6103/D6103M	(2017; E 2021) Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D8167/D8167M	(2023) Standard Test Method for In-Place Bulk Density of Soil and Soil-Aggregate by a Low-Activity Nuclear Method (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-203	(Rev C; Notice 3) Paper, Kraft, Untreated

1.2 DEFINITIONS

1.2.1 Structural Fill

Soil material placed to support buildings, walls, pads, and other similar facilities.

1.2.2 Embankment Fill

Soil material placed to construct embankment.

1.2.3 Porous Fill

Free-draining material placed for subsurface drainage, as a capillary break, or another specific purpose.

1.2.4 Topsoil

Surface layer of primarily organic soil capable of supporting vegetation growth.

1.2.5 Utility Bedding Material

Fill placed to directly support pipes, conduits, cables, and appurtenant structures. Bedding may also be used to provide a cushion between utilities and bedrock, obstacles, obstructions and other unyielding materials.

1.2.6 Satisfactory Materials

Satisfactory materials for fill, backfill, and/or any in-situ soils to remain in place comprise any materials classified by ASTM D2487 as [GW], [GP], [GM], [GP-GM], [GW-GM], [GC], [GP-GC], [GM-GC], [SW], [SP], [SM], [SW-SM], [SC], [SW-SC], [SP-SM], [SP-SC]. Maximum particle size to be no greater than 3 inches] in any dimension.

1.2.7 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; roots and other organic matter or frozen material. Notify the Contractor/Buyer when encountering any contaminated materials.

1.2.8 Cohesionless Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.9 Cohesive Materials

Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines are plastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C117, ASTM C136/C136M and ASTM D1140.

1.2.10 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock". These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.2.11 Unstable Material

Unstable materials are too weak to adequately support the utility pipe, conduit, equipment, or appurtenant structure. Satisfactory material may become unstable due to ineffective drainage, dewatering, becoming frozen, excessive loading.

1.2.12 Expansive Soils

Expansive soils are defined as soils that have an expansion index greater than 20 when tested in accordance with ASTM D4829.

1.2.13 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.14 Degree of Compaction (Proctor)

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in [ASTM D1557] [ASTM D698] abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the ¾-inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the ¾-inch sieve as a percentage of the maximum density in accordance with AASHTO T 180-21 paragraph 1.5, Note 1.

1.2.15 Degree of Compaction (Relative Density)

Degree of compaction required for soils with less than 5 percent passing the No. 200 sieve, is expressed as a relative percentage of the maximum index density/dry unit weight and minimum index density/dry unit weight, obtained by the test procedures in accordance with ASTM D4253 and ASTM D4254, respectively, abbreviated as a percent of laboratory relative density.

1.2.16 Borrow

Soil brought to the project site from an external location for the purposes of project construction.

1.2.17 Subgrade

Earth materials directly below foundations and directly below granular base materials in building slab and pavement areas including shoulders.

1.3 CRITERIA FOR BIDDING

Base bids on the following criteria:

a. Surface elevations are as indicated.

b. Pipes or other artificial obstructions, except those indicated, will not be encountered.

c. Ground water elevation is 100 feet below existing surface elevation.

d. Material character is indicated by the boring logs.

e. Hard materials will not be encountered in the excavations.

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Geotextiles

SD-06 Test Reports

Pipe Pressure Test Report;

Borrow Soil Test Report

1.5 QUALITY CONTROL

1.5.1 Qualified Technician

Provide a Qualified Technician to inspect, monitor, sample, and performing field testing. The technician qualifications need to be one of the following: a current National Institute for Certification in Engineering Technologies (NICET) Level II minimum certification in Construction Materials Testing Soils; a Geologist-in-Training with minimum one-year experience; an Engineer-in-Training with minimum one-year experience; a Registered Geologist; or a Professional Engineer.

1.5.2 Lab Validation

Perform testing by a Corps validated commercial testing laboratory or Subcontractor established testing laboratory approved by the Contractor/Buyer. Submit testing laboratory validation for the testing to be performed. Do not permit work requiring testing until approved by the Contractor/Buyer.

1.5.3 Preconstruction Meeting

Conduct a preconstruction meeting at least five business days prior to the start of earthwork operations on the project. The preconstruction meeting is to be arranged by the Subcontractor and is to follow the written agenda submitted prior to the meeting. The purpose of this meeting is to review the requirements of this specification and the associated plans. The following individuals must be in attendance at this meeting: Subcontractor's Project Manager and Project Superintendent, earthwork subcontractor's Project Manager and Site Foreman, and Contractor/Buyer Construction Manager and Engineering Technician.

The minutes of this meeting are to be recorded by the Subcontractor and published via email within 48 hours to all attendees. The minutes must be re-published within 48 hours via email pending any subsequent comments from the attendees.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Structural Fill

Materials classified as [GW], [GP], [GM], [GC], [GW-GM], [GW-GC], [GP-GM], [GP-GC], [GC-GM], [SW], [SP], [SM], [SW-SM], [SC], [SW-SC], [SP-SM], or [SP-SC], in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

2.1.2 Embankment Fill

Materials classified as [GW], [GP], [GM], [GC], [GW-GM], [GW-GC], [GP-GM], [GP-GC], [GC-GM], [SW], [SP], [SM], [SW-SM], [SC], [SW-SC], [SP-SM], [SP-SC], [CL], or [CH] in accordance with ASTM D2487. Select material type appropriate for the intended purpose.

2.1.3 Topsoil

Material suitable for topsoil obtained from excavations is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than 1 inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth.

2.1.4 Utility Bedding Material

Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with [AWWA C600] [ASTM D2321]. Install bedding for plastic piping to spring line of pipe. Utility bedding material may include the following:

2.1.4.1 Sand

Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill.

2.2 BURIED WARNING AND IDENTIFICATION MARKERS

Provide [polyethylene plastic] [and] [metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic] warning tape manufactured specifically for warning and identification of buried utility lines.

Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Warning Tape Color Codes	
Red	Electric
Yellow	Gas, Oil; Dangerous Materials
Orange	Telephone and Other Communications
Blue	Water Systems
Green	Sewer Systems
White	Steam Systems
Gray	Compressed Air

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.2.3 Detection Wire for Non-Metallic Piping

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.2.4 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, or poorly graded with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than 6.

2.3 GEOTEXTILE

Provide a pervious sheet of polyester, nylon, glass or polypropylene ultraviolet resistant filaments woven, spun bonded, fused, or otherwise manufactured into a non-raveling fabric with uniform thickness and strength. Fabric must have manufacturer certified minimum average roll properties that conform with SECTION 31 05 19.13. Submit a sample and material product data for all Geotextiles utilized.

PART 3 EXECUTION

3.1 PROTECTION

Perform all work specified in accordance with applicable requirements of the Corps of Engineers publication EM 385-1-1 Safety and Health Requirements Manual.

Use equipment of type and size appropriate for the site conditions (soil character and moisture content). Maintenance of exposed subgrades and fills is the responsibility of the Subcontractor. The Subcontractor is required to prevent damage by ineffective drainage, dewatering, and heavy loads and equipment by implementing precautionary measures. Repair or replace any defects or damage.

3.1.1 Underground Utilities

Location of the existing utilities indicated is approximate. Physically verify the location and elevation of the existing utilities indicated prior to starting construction. The Subcontractor is responsible for protecting utilities from damage during construction.

3.1.2 Drainage and Dewatering

Provide for the collection and disposal of surface and subsurface water encountered during construction.

3.1.2.1 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Throughout construction grade the construction area to provide positive surface water runoff away from the construction activity or provide temporary ditches, swales, and other drainage features and equipment as required to keep soils from becoming unstable, prevent erosion, or undermining of foundations. Remove unstable material from working platforms for equipment operation and soil support for subsequent construction features and provide new material as specified herein. It is the responsibility of the Subcontractor to assess the site conditions to employ necessary measures to permit construction to proceed.

3.1.3 Protection of Graded Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.1.4 Government Furnished Borrow Area(s)

Obtain approved borrow materials from Operable Unit 2 Landfills. The rights-of-way and earth materials for constructing the work have been furnished, without cost, to the Subcontractor at locations as specified. Submit a Borrow Plan to the Contractor/Buyer of intention to use the specified Government-furnished borrow areas.

3.1.4.1 Drainage of Borrow Excavations

Provide adequate drainage of borrow area. Ensure that borrow operations result in minimum detrimental effects on natural environmental conditions.

3.1.4.2 Borrow Area Closure

Complete borrow areas final grading, so that slopes are not steeper than 3 vertical on 1 horizontal, except as otherwise indicated. Avoid abrupt changes in grade. Distribute stripped material and stockpiles of unstable materials over the disturbed borrow area, as directed. Final grade the borrow area to drain.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing

Clear and grub as specified in Section 31 11 00 CLEARING AND GRUBBING. Remove trees, stumps, logs, shrubs, brush and vegetation and other items that would interfere with construction operations. Remove stumps entirely. Grub out matted roots and roots over 3 inches in diameter to at least 18 inches below existing surface.

3.2.2 Stripping

Strip site where indicated on the plans. Strip existing surface materials to a depth of 6 inches below the existing ground surface in areas designated as Clear and Grub on the plans. Strip existing surficial soils to a depth of 3 inches in all other areas. All stripped materials not suitable for reuse as topsoil will be wasted in specified disposal area.

Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Protect topsoil and keep in segregated piles until needed.

3.3.4 Stockpiling Operations

Place and grade stockpiles of satisfactory, unsatisfactory, and wasted materials as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. Do not create stockpiles that could endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way. If the Subcontractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.3 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Excavate soil disturbed or weakened by Subcontractor's operations, and soils softened or made unstable for subsequent construction due to exposure to weather. Use material removed from excavations meeting the specified requirements in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes to minimize surplus material and to minimize additional material to brought on site. Do not excavate below indicated depths except to remove unstable material as determined by the Contractor/Buyer. Remove and replace excavations below the grades shown with appropriate materials as directed by the Contractor/Buyer.

If at any time during excavation, including excavation from borrow areas, the Subcontractor encounters material that may be classified as rock or as hard/unyielding material, uncover such material, and notify the Contractor/Buyer. Do not proceed with the excavation of this material until the Contractor/Buyer has classified the materials as common excavation or rock excavation. Failure on the part of the Subcontractor to uncover such material, notify the Contractor/Buyer, and allow sufficient time for classification and delineation of the undisturbed surface of such material will cause the forfeiture of the Subcontractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Contractor/Buyer for the areas of work in which such deposits occur.

3.3.1 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended by the manufacturer. Provide vertical trench walls where no manufacturer installation instructions are available. Do not exceed the trench width of 24 inches below the top pipe plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger pipe, or special installation procedures. The Subcontractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the

Contractor/Buyer.

3.3.1.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 1 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.3.1.2 Removal of Unyielding Material

Where unyielding material is encountered in the bottom of the trench,, remove such material 2 inches below the required grade and replaced with suitable materials as provided in paragraph FILLING AND COMPACTION.

3.3.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with suitable material as provided in paragraph FILLING AND COMPACTION. When removal of unstable material is required due to the Subcontractor's fault or neglect in performing the work, the Subcontractor is responsible for excavating the resulting material and replacing it without additional cost to the Contractor/Buyer.

3.3.1.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members or of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown.

3.3.1.5 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

3.3.1.6 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.3.1.7 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight segmented elastomeric end seals.

3.3.2 Underground Utilities

Excavation made with power-driven equipment is not permitted within 2 feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Contractor/Buyer.] Report damage to utility lines or subsurface construction immediately to the Contractor/Buyer.

3.4 SUBGRADE PREPARATION

3.4.1 General Requirements

Shape subgrade to line, grade, and cross section as indicated. Remove unsatisfactory and unstable material in surfaces to receive fill or in excavated areas, and replace with structural fill. Do not place material on surfaces that are muddy, frozen, contain frost, or otherwise containing unstable material. Scarify the surface to a depth of 4 inches prior to placing fill. Step or bench sloped surfaces steeper than 1 vertical to 4 horizontal prior to scarifying. Place 4 inches of loose fill and blend with scarified material. When subgrade is part fill and part excavation or natural ground, scarify to a depth of 8 inches.

3.4.2 Subgrade Filter Fabric

Place filter fabric as indicated directly on prepared subgrade free of vegetation, stumps, rocks larger than 2 inch diameter and other debris which may puncture or otherwise damage the fabric. Repair damaged fabric by placing an additional layer of fabric to cover the damaged area a minimum of 3 feet overlap in all directions. Overlap fabric at joints a minimum of 3 feet. Obtain approval of filter fabric installation before placing fill or backfill. Place fill or backfill on fabric in the direction of overlaps and compact as specified herein. Follow manufacturer's recommended installation procedures.

3.5 FILLING AND COMPACTION

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs for SUBGRADE PREPARATION. Do not place material on surfaces that are muddy, frozen, or contain frost. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Moisten material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Fill and backfill to contours, elevations, and dimensions indicated. Compact and test each lift before placing overlaying lift.

3.5.1 Trench Backfill

Backfill trenches to the grade shown. Backfill the trench to 2 feet above the top of pipe prior to performing the required pressure tests. Leave the joints and couplings uncovered during the pressure test. Do not backfill the trench until all specified tests are performed.

3.5.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with satisfactory material or initial backfill material.

3.5.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with satisfactory material placed in layers not exceeding 6 inches loose thickness.

3.5.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except where shown or when specified otherwise in the individual piping section, provide bedding for buried piping in accordance with PART 2 paragraph UTILITY BEDDING MATERIAL. Compact backfill to top of pipe to 85 percent of ASTM D1557. Provide plastic piping with bedding to spring line of pipe.

3.5.1.4 Final Backfill

Do not begin backfill until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Bring backfill to indicated finish grade. Heavy equipment for spreading and compacting backfill are not to be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; compact remaining area in layers not more than 4 inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Place backfill carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Do not place backfill against foundation walls prior to 7 days after completion of the walls. As far as practicable, bring backfill up evenly on each side of the wall and sloped to drain away from the wall.

Fill the remainder of the trench, except for special materials for buildings and pavements with satisfactory material. Place backfill material and compact as follows:

3.5.1.4.1 Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Allow water flooding or jetting methods of compaction for granular non-cohesive backfill material. Do not allow water jetting to penetrate the initial backfill. Apply this requirement to all other areas not specifically designated above.

3.5.1.5 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.5.1.6 Buried Tape And Detection Wire

3.5.1.6.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape

12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.5.1.6.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal.

3.5.2 Backfill for Appurtenances

After the manhole, catch basin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.5.3 Flowable Fill

Place fill in a manner to completely fill voids in the location indicated. Do not place when atmospheric temperatures are expected to be below 33 degrees F at any time during the 3 day period following placement.

3.5.4 Compaction

3.5.4.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to 85 percent of [ASTM D698] [ASTM D1557].

3.6 EMBANKMENTS

3.9 FINISHING/FINISH OPERATIONS

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, frozen or otherwise unstable subgrade.

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except as indicated for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.9.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Subcontractor's operations, grade as directed.

3.9.2 Topsoil and Seed

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 2 inches and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Remove from the site any surplus of topsoil from excavations and gradings. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from Operable Unit 2 Landfills.

3.10 DISPOSITION OF SURPLUS MATERIAL

Remove from Government property all surplus or other soil material not required or not suitable for filling or backfilling, along with brush, refuse, stumps, roots, and timber. Properly disposed of in accordance with all applicable laws and regulations. Prepare plan for Disposition of Surplus Materials to include permissions document to dispose of nonsalable products.

3.11 TESTING

Perform testing as indicated in Table 1. Submit Material Test Reports within 7 days of tests being completed.

Material Type [list materials to be tested as identified in paragraph DEFINITIONS]	Location of Material	Test Method	Test Frequency
		Density - [ASTM D1556/D1556M] [ASTM D2167] [ASTM D6938] [ASTM D8167/D8167M]. [When ASTM D6938 or ASTM D8167/D8167M is used, check the calibration curves and adjust using only the sand cone method as described in ASTM D1556/D1556M.]	One test per [2000] [___] square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines. [If ASTM D6938 or ASTM D8167/D8167M is used, check in-place densities by ASTM D1556/D1556Mn as follows: One check test per lift for every [6] [10] tests.] [Where ASTM D8167/D8167M is used, provide water Content verification in
		Relative Density - ASTM D4253 and ASTM D4254	One test per [2000] [___] square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines. Double testing frequency for areas compacted by hand-operated machines.

-- End of Section --

SECTION 31 05 19.13: GEOTEXTILES FOR EARTHWORK
02/21

PART 1 GENERAL

1.1.1 Measurement

Installed geotextiles will be measured for payment in place to the nearest 10 square feet of protected area as delineated in the drawings.

1.1.2 Unit of Measure

Unit of measure: square feet.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D123	(2015b; R 2017) Standard Terminology Relating to Textiles
ASTM D4354	(2012; R 2020) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2017) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2020) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D4884/D4884M	(2014a) Strength of Sewn or Thermally Bonded Seams of Geotextiles
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 1110-2-1601	(1991; 1994 Change 1) Engineering and Design -- Hydraulic Design of Flood Control Channels

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-07 Certificates

Geotextiles

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver only approved geotextile [rolls] to the project site. Label, ship, store, and handle all geotextile in accordance with ASTM D4873/D4873M. Do not use hooks, tongs, or other sharp instruments for handling geotextile.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 General

Provide geotextile that is a [woven][non-woven] pervious sheet of plastic yarn as defined by ASTM D123 matching or exceeding the minimum average roll values listed in TABLE 1. Strength values indicated in the table are for the weaker principal direction.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	lb	120	ASTM D4632/D4632M
SEAM STRENGTH	lb	50	ASTM D4632/D4632M
PUNCTURE	lb	50	ASTM D6241
TRAPEZOID TEAR	lb	223	ASTM D4533/D4533M
PERMEABILITY	cm/sec	1.7	ASTM D4491/D4491M
APPARENT OPENING SIZE	U.S. SIEVE	70	ASTM D4751
PERMITTIVITY	sec -1	1.7	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	Percent strength	70 at 500 Hrs	ASTM D4355/D4355M

2.1.2 Geotextile Fiber

Use fibers consisting of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polyamides. Add stabilizers and/or inhibitors to the base polymer, if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Do not add reclaimed or recycled fibers or polymer to the formulation. Form geotextile into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile.

2.1.3 Seams

Sew the seams of the geotextile with thread of a material meeting the chemical requirements given above for geotextile yarn or bond the seams by cementing or by heat. Attach the sheets of geotextile at the factory or another approved location, if necessary, to form sections not less than 8 feet wide. Test seams in accordance with method ASTM D4884/D4884M. Seam strength less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction is not permitted.

2.1.4 Securing Pins

Secure the geotextile to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Insert securing pins through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Remove securing pins as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes. Maximum spacing between securing pins depends on the steepness of the embankment slope. Provide maximum pins spacing equal to or less than the values listed in TABLE 2. When windy conditions prevail at the construction site, increase the number of pins upon the demand of the Contractor/Buyer. Anchor terminal ends of the geotextile with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

TABLE 2
MAXIMUM SPACING FOR SECURING PINS

EMBANKMENT	SPACING, feet
STEEPER THAN 1V ON 3H	2
1V ON 3H TO 1V ON 4H	3
FLATTER THAN 1V ON 4H	5

2.2 INSPECTIONS, VERIFICATIONS, AND TESTING

2.2.1 Manufacturing and Sampling

Provide geotextiles and factory seams meeting the requirements specified in TABLE 1.

2.2.1.1 Conformance Testing

Perform conformance testing in accordance with the manufacturers approved quality control manual. Submit manufacturer's quality control conformance test results.

2.2.1.2 Factory Sampling

Randomly sample geotextiles in accordance with ASTM D4354 (Procedure Method A). Sample factory seams at the frequency specified in ASTM D4884/D4884M. Provide all samples from the same production lot as will be supplied for the contract, of the full manufactured width of the geotextile by at least 10 feet long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 5 feet. Identify samples submitted for testing by manufacturers lot designation.

2.2.1.3 Needle Punched Geotextile

For needle punched geotextile, provide manufacturer certification that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

2.2.1.4 Manufacturer Certification

All brands of geotextile and all seams to be used will be accepted on the basis of mill certificates or affidavits. Submit duplicate copies of the mill certificate or affidavit signed by a legally authorized official from the company manufacturing the geotextile. Attest that the geotextile meets the chemical, physical and manufacturing requirements stated in this specification.

2.2.2 Site Verification and Testing

Collect samples at approved locations upon delivery to the site in accordance with ASTM D4354

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Prepare surface, on which the geotextile will be placed, to a relatively smooth surface condition in accordance with the applicable portion of this specification and must be free from obstruction, debris, depressions, erosion feature, or vegetation. Remove any irregularities so as to ensure continuous, intimate contact of the geotextile with all the surface. Remove loose material, soft or low density pockets of material; grade erosion features such as rills and gullies out of the surface before geotextile placement.

3.2 INSTALLATION OF THE GEOTEXTILE

3.2.1 General

Place the geotextile in the manner and at the locations shown. At the time of installation, reject the geotextile if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

3.2.2 Placement

Place the geotextile with the long dimension parallel to the centerline of the trench and laid smooth and free of tension, stress, folds, wrinkles, or creases. Place the strips to provide a minimum width of 12 inches of overlap for each joint. Adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the [bedding layer] is placed will be allowed. Remove the temporary pins as the bedding is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Perform trimming in such a manner that the geotextile is not damaged in any way.

3.3 PROTECTION

Protect the geotextile at all times during construction from contamination by surface runoff; remove any geotextile so contaminated and replaced with uncontaminated geotextile. Replace any geotextile damaged during its installation or during placement of [bedding materials] at no cost to the Contractor/Buyer. Schedule the work so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply will require replacement of geotextile.

Protect the geotextile from damage prior to and during the placement of materials. This may be accomplished by limiting the height of drop to less than 1 foot, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials will not impede the flow of water. Before placement of materials, demonstrate that the placement technique will not cause damage to the geotextile. Do not allow equipment on the unprotected geotextile.

3.4 PLACEMENT OF CUSHIONING MATERIAL

Perform placing of cushioning material in a manner to ensure intimate contact of the geotextile with the prepared surface and with the cushioning material. Do not damage the geotextile, including tear, puncture, or abrasion, during placement. On sloping surfaces place the cushioning material from the bottom of the slopes upward. Uncover any geotextile damaged beneath the cushioning material, as necessary, and replaced at no cost to the Contractor/Buyer.

3.5 OVERLAPPING AND SEAMING

3.5.1 Overlapping

The overlap of geotextile [rolls] must be 12 inches. Appropriate measures will be taken to ensure required overlap exists after cushion placement.

3.5.2 Sewn Seams

High strength thread should be used so that seam test conforms to ASTM D4884/D4884M. Provide thread meeting the chemical, ultraviolet, and physical requirements of the geotextile, and provide color different from that of the geotextile. Provide seam strength equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Use double sewing, especially for field seams, to provide a safety factor against undetected missed stitches.

-- End of Section --

SECTION 31 11 00: CLEARING AND GRUBBING
11/18

PART 1 GENERAL

1.1 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

1.2 DELIVERY, STORAGE, AND HANDLING

Deliver materials to the site, and handle in a manner which will maintain the materials in their original manufactured or fabricated condition until ready for use.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Tree Wound Paint

Use bituminous based paint from standard manufacture specially formulated for tree wounds.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Protection

3.1.1.1 Roads and Walks

Keep roads and walks free of dirt and debris at all times.

3.1.1.2 Trees, Shrubs, and Existing Facilities

[Protect trees and vegetation to be left standing from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.]

3.1.1.3 Utility Lines

3.2 Protect existing utility lines that are indicated to remain from damage. Notify the Contractor/Buyer immediately of damage to or an encounter with an unknown existing utility line. The Subcontractor is responsible for the repair of damage to existing utility lines that are indicated or made known to the Subcontractor prior to start of clearing and grubbing operations. When utility lines which are to be removed are encountered within the area of operations, notify the Contractor/Buyer in ample time to minimize interruption of the service. CLEARING

Clearing consists of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. [Clearing also includes the removal and disposal of structures that obtrude, encroach upon, or otherwise obstruct the work.] Cut off flush with or below the original ground surface trees, stumps, roots, brush, and other vegetation in areas to be cleared, except such trees and vegetation as may be indicated or directed to be left standing. Trim dead branches 1½ inches or more in diameter on trees designated to be left standing within the cleared areas and trim all branches to the heights indicated or directed. Neatly cut close to the bole of the tree or main branches, limbs and branches to be trimmed. Paint, with an approved tree-wound paint, cuts more than 1½ inches in diameter. Apply herbicide [in accordance with the manufacturer's label] to the top surface of stumps designated not to be removed.

3.2.1 Tree Removal

Where indicated or directed, remove trees and stumps that are designated as trees from areas outside those areas designated for clearing and grubbing. This work includes the felling of such trees and the removal of their stumps and roots as specified in paragraph GRUBBING. Dispose of trees as specified in paragraph DISPOSAL OF MATERIALS.

[3.2.2 Pruning

[Prune] [Trim] trees designated to be left standing within the cleared areas of dead branches 1½ inches or more in diameter; and trim branches to heights and in a manner as indicated. Neatly cut limbs and branches to be trimmed close to the bole of the tree or main branches. Paint cuts more than 1¼ inches in diameter with an approved tree wound paint.

]3.2.3 Grubbing

Grubbing consists of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove material to be grubbed, together with logs and other organic or metallic debris not suitable for foundation purposes, to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated as construction areas under this contract, such as areas for buildings, and areas to be paved. Fill depressions made by grubbing with suitable material and compact to make the surface conform with the original adjacent surface of the ground.

3.3 DISPOSAL OF MATERIALS

Dispose of excess materials in accordance with the approved solid waste management permit and include those materials in the solid waste management report.

All wood or wood like materials, except for salable timber, remaining from clearing, pruning or grubbing such as limbs, treetops, roots, stumps, logs, rotten wood, and other similar materials is the property of the Subcontractor and dispose of as specified. All non-saleable timber and wood or wood like materials remaining from timber harvesting such as limbs, treetops, roots, stumps, logs, rotten wood, and other similar materials is the property of the Subcontractor and dispose of as specified.

-- End of Section --

SECTION 33 51 39: MONITORING WELLS

08/17

PART 1 GENERAL

1.1 UNIT PRICES

Payment for each specified item is made at the contract unit price for that item. Payment includes full compensation for equipment, materials and labor for drilling; removal and disposal of temporary casing, cuttings, and drill fluid; preparation of borehole logs; and sample handling, containers, storage, and testing. Measure depth, logging, installation, casing, riser pipe, and well screen by linear distance. Payment is not allowed for test holes or wells abandoned due to construction practices not in accordance with this specification, or for the convenience of the Subcontractor. Submit catalog data for the well screen (to include the screen slot size), well casing, riser pipe, filter pack material, Bentonite, cement, centralizers, surface protective covers, well vaults, locking caps, airline oil filters for pneumatic drilling, dedicated sampling equipment, and chemical specifications on drill lubricants and tracers, if used. Include any information, written or otherwise, supplied by the manufacturers or suppliers of the above listed items.

1.1.1 Test Holes

If the total depth of the test hole is greater than that specified in the contract for "Test Holes and Samples" due to justifiable site specific conditions and other justifiable reasons, the additional depth is paid for at the contract unit price for "Additional Test Hole Depth." If the test hole is developed into the permanent monitoring well, no separate payment is made for the test hole.

1.1.2 Well Drilling and Sampling

If the total depth of the well is greater than that specified in the contract for "Monitoring Wells and Samples," the additional depth is paid for at the contract unit price for "Additional Test Hole Depth."

1.1.3 Geophysical Logging

The "Geophysical Logging" unit price includes interpretation of the logs and their delivery to the Government.

1.1.4 Well Casing and Riser Pipe Selection and Installation

Payment is made for length of blank casing actually installed in the well. Payment includes compensation for decontamination and installation of the casing, riser pipe, cap, tail piece (if any), end cap and centralizers; and for the furnishing and installing of the well identification tag with information recorded thereon, or well marking in accordance with contract.

1.1.5 Monitoring Well Screen

Payment is made for monitoring well screen actually installed in the well.

1.1.6 Filter Pack Construction

Filter pack construction is measured by the cubic foot. Payment includes compensation for furnishing, delivering, storage, decontamination, analytical testing, and installing the filter pack.

1.1.7 Bentonite Seal

The bentonite seal is measured by the cubic foot. Payment includes full compensation for hydrating, and tremieing necessary for the work.

1.1.8 Grout Placement

The cement and/or bentonite grout used in the annulus above the bentonite seal is paid by the cubic foot used. Payment includes compensation for cement, mixing of the grout, and pumping of grout, bentonite, mixing of bentonite grout, and pumping of bentonite grout, necessary for the work.

1.1.9 Monitoring Well Development

Payment for monitoring well development is made by the hour. Payment includes compensation for pumping, surging, sample photograph, discharge water containers, analysis, and disposal.

1.1.10 Monitoring Well Completion Aboveground

Payment includes compensation for protective covers, keyed-alike padlocks, locking caps, project photographs, concrete well pads, gravel, electrical components, lighting components, fencing, sign(s) and protective steel posts.

1.1.11 Monitoring Well or Test Hole Decommissioning/Abandonment

Permanent decommissioning/abandonment of monitoring wells or test holes is paid for only if it becomes necessary to abandon a well or test hole as specified, and only for work completed and accepted as specified. Payment includes compensation for drilling, casing removal, well sampling, materials, cement, mixing of cement, bentonite, and water, pumping of grout, equipment, removal of foreign objects, and transportation necessary to abandon the well or test hole and for the required well or test hole abandonment records.

1.1.12 Site Cleanup

Separate payment is not made for cleanup of the site. Cleanup means restoring the site to its pre-construction condition. Cleanup is considered part of and incidental to the drilling, construction, and/or decommissioning of the monitoring well.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 306	(2010; R 2015) Standard Specification for Drainage, Sewer, Utility, and Related Castings

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2017) Standard Methods for the Examination of Water and Wastewater

ASTM INTERNATIONAL (ASTM)

ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A312/A312M	(2022a) Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM C117	(2017) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C150/C150M	(2022) Standard Specification for Portland Cement
ASTM C387/C387M	(2017) Standard Specification for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar
ASTM D1452/D1452M	(2016) Standard Practice for Soil Exploration and Sampling by Auger Borings
ASTM D1586/D1586M	(2018) Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D1587/D1587M	(2015) Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
ASTM D1785	(2015; E 2018) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D2216	(2019) Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2017; E 2018) Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and

	Plasticity Index of Soils
ASTM D4397	(2016) Standard Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications
ASTM D5088	(2020) Decontamination of Field Equipment Used at Nonradioactive Waste Sites
ASTM D5092	(2016) Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers
ASTM D5521/D5521M	(2013) Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers
ASTM D5608	(2016) Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
ASTM D6725/D6725M	(2016) Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
ASTM F480	(2014; R 2022) Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), SCH 40 and SCH 80
ASTM F883	(2013; R 2022) Standard Performance Specification for Padlocks

FORESTRY SUPPLIERS INC. (FSUP)

FSUP 77341	(2009) Munsell (R) Soil Color Book

GEOLOGICAL SOCIETY OF AMERICA (GeoSA)

GSA RCC00100R	(2009) Geological Rock Color Chart (Munsell)

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety – Safety and Health Requirements Manual

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 530/F-93/004	(1993; Rev O; Updates I, II, IIA, IIB, and III) Test Methods for Evaluating Solid Waste (Vol IA, IB, IC, and II) (SW-846)
EPA 600-4-89-034	(1990) Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells
EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes

EPA SW-846	(Third Edition; Update IV) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards
49 CFR 172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements

1.3 ADMINISTRATIVE REQUIREMENTS

Ensure each system, including equipment, materials, installation, and performance, is in accordance with local, State, and Federal regulations, ASTM D5092, EPA 600-4-89-034 and DoD policies and standards except as modified herein. Consider the advisory or recommended provisions to be mandatory.

1.3.1 Notification

Notify the Contractor 14 calendar days prior to drilling. The Contractor is responsible for contacting the State of California and USEPA in accordance with the applicable reporting requirements.

1.4 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

QAPP (prepared by Contractor), to include Investigation-derived

Waste Management Plan; Installation Plan; Sampling and Analysis

Plan;

Well Construction Permit (obtained by Contractor);

Accident Prevention Plan (prepared by Contractor)

SD-02 Shop Drawings

Survey Maps and Notes;

Well Construction Drawings;

SD-03 Product Data

Riser Pipe;

Cement; Centralizers;

Surface Protective Covers; Well Vaults;

Oil Filters; Sampling Equipment;
Chemical Specifications on Drill Lubricants and Tracers;

Well Casing;

Well Screen;

Filter Pack;

Neat Cement Grout; Bentonite;

SD-06 Test Reports

Drilling Fluid Additive; Well Development Record; Filter Pack

Material Test Results; Sieve Analyses of Sampled Material; Water

Source Analytical Test Results

SD-07 Certificates Permits

Installation Survey Report;

Well Development Report;

Borehole Analysis Report;

Correspondence;

Photographs

SD-11 Closeout Submittals

Installation Diagram;

Well Decommissioning/Abandonment Record;

Geophysical Logs;

Borehole Logs

1.5 QUALITY CONTROL

1.5.1 Qualifications

Contractor to provide an onsite geologist with at least 3 years' experience in hazardous waste projects, soil and rock logging, and monitoring well installation. Ensure the geologist is registered in the State of CA, and responsible for all geophysical and borehole logging, drilling, well installation, developing and testing activities. Provide a driller licensed in the State of CA, according to State requirements. Perform and provide geophysical log interpretation by a qualified log analyst, demonstrating competence through background, training, and experience when so called upon. Ensure the drill crew is experienced and trained in drilling, and health and safety requirements for contaminated sites.

The Contractor shall furnish documentation proving:

a. A minimum of 3 years of monitor well installation experience

b. Appropriate health and safety personnel are on staff

c. That qualified personnel are available to perform the necessary chemical sampling as presented in the approved QAPP.

1.5.2 Required Drawings

The Contractor shall submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Ensure drawings are prepared and sealed by a State certified professional geologist, hydrogeologist, or a State registered professional civil engineer, hereafter referred to as the Contractor's Professional Consultant (CPC).

1.5.3 Investigation-derived Waste Management Plan

The Contractor shall furnish a material handling plan 15 days prior to initiation of the work that describes the plan for handling the investigation-derived waste, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling and development, material hauling, proposed equipment, handling of the investigation-derived waste, testing requirements for the investigation-derived waste.

1.5.4 Accident Prevention Plan (APP)

The Contractor shall provide an APP to describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and EM 385-1-1. Identify safety equipment and procedures available for use during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.

1.5.5 Quality Assurance Project Plan (QAPP)

The Contractor shall provide a QAPP to describe field sampling methods, quality control procedures, and identify a certified laboratory with laboratory methods to be used for contamination testing. Ensure sample reports show sample identification with location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, quality control procedures, and chain of custody information.

1.5.6 Installation Plan

The Contractor shall submit a plan, describing the drilling methods, sampling, and monitoring well construction and well development 30 calendar days prior to beginning drilling operations. Mobilization activities may start prior to submittal of the plan. Provide the plan approved and signed by a geologist as specified in the paragraph QUALIFICATIONS. Incorporate the following requirements into the Monitoring Well Installation Plan and follow in the field. Include in the plan, but do not limit to a discussion of the following:

a. Description of well drilling methods, and installation procedures, including any temporary casing used, placement of filter pack and seal materials, drill cuttings and fluids disposal, and soil/rock sample disposition.

b. Description of well construction materials, including well screen, riser pipe, centralizers, tailpiece (if used), filter pack and filter pack gradation, bentonite, drilling fluid additives (if used), drilling water, cement, and well protective measures.

c. Description of quality control procedures to be used for placement of filter pack and seals in the boring, including depth measurements.

d. Include sample of forms used for written boring logs, installation diagrams of wells, geophysical logs, well development records, well sampling data records, State well registration forms, and well abandonment records.

e. Description of contamination prevention. Describe decontamination procedures for well materials and equipment.

f. Description of well development methods to be used.

g. List of applicable publications, including State and local regulations and standards.

h. List of personnel assignments for this project, and personnel qualifications.

i. Description of in-situ permeability determination techniques if testing is required.

j. Description and discussion of geophysical techniques to be employed at the site.

1.5.7 Well Development Report

Provide a report, containing the following data: project name and location, well designation, date and time of well installation, date and time of well development, static water level from top of well casing before development and 24 hours after development, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.

1.5.8 Well Construction Permit

The Contractor shall submit a completed permit application and a proposed method of construction to the appropriate state agency prior to construction of the well. Well construction is not allowed to start until the Contractor/Buyer has an approved Well Construction Permit.

1.6 DELIVERY, STORAGE, AND HANDLING

Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store plastic piping and jointing materials, and rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

1.7 PROJECTS/SITE CONDITIONS

Access to each monitoring well site, including any utility clearance, permits, licenses, or other requirements and the payment thereof necessary for execution of the work is the responsibility of the Contractor.

Before beginning work, the Contractor shall notify the local health department of the type and location of wells to be constructed, the method of construction and anticipated schedule for construction of the wells.

Obtaining rights-of-entry is the responsibility of the Government. Visit each proposed well location to observe any condition that may hamper transporting equipment or personnel to the site. If clearing or relocation is necessary, the Subcontractor, Contractor, and the Government will agree on a suitable clearing, or relocation plan and the location of any required access road.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The screened interval is that portion of a monitoring well which is directly open to the host aquifer by way of openings in the well screen and indirectly open to the aquifer by way of the filter pack (or other permeable material) extending continuously below and/or above the screen.

2.2 COMPONENTS

2.2.1 Well Casing

2.2.1.2 PVC Pipe

Use ASTM F480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule 80 pipe, with flush threaded joint fittings. Wrap threaded joints with fluoropolymer tape, and provide with nitrile O-ring gaskets.

2.2.2 Well Screen

2.2.2.1 Stainless Steel Screens

Provide a well screen consisting of new commercially fabricated flush-joint threaded 10-inch nominal internal diameter Type 316 stainless steel continuous wrap, non-clogging design. Use screens conforming to ASTM A312/A312M, Type 316, Schedule 40S, with continuous slot construction, wire wound, with flush threaded joint ends. Provide schedule 40 end fittings on the continuous wrap screen. Provide a screen slot size 0.045-inch, and screen length of 40 feet. Seal the bottom section of the screen watertight by means of a flush threaded end cap of the same material as the well screen, within 6 inches of the open portion of the screen.

2.2.3 Primary Filter Pack

Provide a filter pack consisting of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Organic matter, soft, friable, thin, or elongated particles are not permissible. Use a uniformity coefficient for the filter pack material not exceeding 2.5. Fill an airtight pint size [plastic] [glass] container with a sample of filter pack material and furnish to the Contractor/Buyer for each well to serve as a quality control.

2.2.3.1 Secondary Filter Pack

Ensure gradation is in accordance with ASTM D5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack cannot contain organic matter or friable materials.

2.2.4 Annular Sealants

2.2.4.1 Bentonite Seal

Provide powdered, granular, pelletized, or chipped [sodium] [calcium] montmorillonite in sealed containers from a commercial source, free of impurities. Ensure pellet size is less than one fifth the diameter of the borehole annular space to prevent bridging. Ensure bentonite base grout is in accordance with ASTM D5092.

If the bentonite seal is located above any borehole fluid levels, place a layer of fine sand at the top of the bentonite seal, to provide an additional barrier to any downward migration of grout.

2.2.4.2 Neat Cement Grout

Provide neat cement grout in accordance with ASTM D5092. Ensure cement is in accordance with ASTM C150/C150M. Quick setting admixtures are not allowed. Do not use drilling mud or cuttings as a sealing material.

2.2.4.3 Cement And Bentonite Grout

Provide cement grout with a mixture of a maximum of 7 gallons of approved water per 94 lb bag of Portland cement, conforming to ASTM C150/C150M, Type I or Type II. Add no more than 5 percent by weight of bentonite powder to reduce shrinkage and hold the cement in suspension prior to the grout set. Use sodium bentonite powder and/or granules for high-solids bentonite grout.

2.2.5 Bottom Plugs

Provide a flush threaded solid plug at the bottom of the well. Ensure plug material is the same as the well screen to which it is attached. Wrap joints with fluoropolymer tape and provide nitrile O-ring gaskets.

2.2.6 Polyethylene Sheeting

Ensure polyethylene sheeting conforms to ASTM D4397.

PART 3 EXECUTION

Notify the Contractor/Buyer at least 15 days prior to commencement of work. Well locations are as indicated. Drilling, installation, and development of the monitoring well[s] is supervised, directed, and monitored by the geologist in charge. Decontaminate equipment used for drilling, sampling, and well development before and after each use in accordance with ASTM D5088.

3.1 PREPARATION

3.1.1 Decontamination

Clean the drill rig, drill rods, drill bits, augers, temporary casing, well developing equipment, tremie pipes, grout pumping lines, and other associated equipment with high-pressure hot water/steam prior to drilling at each monitoring well location. Perform decontamination in accordance with [ASTM D5088][ASTM D5608], at a central decontamination station located in an area that is remote from, and cross- or down-gradient from the well being drilled.

Clean the screen and well casing with high-pressure hot water and detergent cleaning solution immediately prior to installation in the well. The use of factory sealed (plastic wrapped) screen and well casing does not waive this requirement for pre-installation cleaning. Decontaminate samplers in accordance with the QAPP.

3.1.2 Decontamination Station

a. Construct a temporary decontamination pad onsite, bermed and slightly inclined towards a sump located in one of the back corners of the pad. Line the pads and berms with plastic sheeting to contain decontamination water. Place exterior-grade plywood sheeting over the plastic sheeting to prevent damage to the plastic and allow the drill rig and heavy equipment to use the pad.

b. Make the minimum dimensions of the pad the length and width of the drill rig, plus 4 feet per side to allow access and steam cleaning. Use yellow ribbon to encircle the decontamination pad.

3.1.3 Containerization Of Development Water, And Drill Cuttings

Furnish D.O.T. approved [polyethylene] [steel] drums or vessels with lids, lid gaskets, bolts, chain of custody forms and drum labels. Mark each drum label in accordance with 49 CFR 172 in addition to the following information:

a. Drum number,

b. Site name,

c. Well name and number,

d. Contents and date,

e. Approximate depth of material contained in each drum, and

f. The name and phone number of the Contractor/Buyer.

3.2 INSTALLATION

Install the well in accordance with California Well Standards, and as indicated on the well construction drawings submitted by the CPC and approved by the Contractor/Buyer.

Prevent aquifer contamination by the drilling operation and equipment, intra- and inter-aquifer contamination, and vertical [or horizontal] seepage of surface water adjacent to the well into the subsurface, especially the monitoring well intake zone. Perform work in conformance with California Well Standards.

Ensure the borehole is stable and verified straight before beginning installation.

3.2.1 Drilling Method

a. Use a drilling method which prevents the collapse of formation material against the well screen and casing during installation of the well. Size the inside diameter of any temporary casing used sufficient to allow accurate placement of the screen, riser, centralizer, filter pack, seal and grout.

b. The use of drilling aids such as bentonite, other clay-based agents, or any other foreign matter capable of affecting the characteristics of the ground water is prohibited. Ensure any drilling fluid additive used is inorganic in nature. Grease or oil on drill rods, casing, or auger joints are not permitted; however, PTFE tape or vegetable oil (in solid phase form) are acceptable. Submit manufacturer's data, if available, including analytical test results of the additive, if not a part of the manufacturer's data.

c. Provide a drill rig free from leaks of fuel, hydraulic fluid, and oil which may contaminate the borehole, ground surface or drill tools. During construction of the wells, use precautions to prevent tampering with the well or entrance of foreign material. Prevent runoff from entering the well during construction. If there is an interruption in work, such as overnight shutdown or inclement weather, close the well opening with a watertight uncontaminated cover. Secure the cover in place or weighted down so that it cannot be removed except with the aid of the drilling equipment or through the use of drill tools.

Advance borehole using conventional sonic and mud rotary drilling methods. If it is the opinion of the geologist in charge that an alternate drilling method is required, submit justification for a boring method change to the Contractor/Buyer, and receive approval for the change granted prior to drilling.

3.2.2 Test Hole Requirements

Drill one test hole for every monitoring well or well cluster installed. A well cluster, as defined in this specification, is two or more wells completed (screened) to different depths in a single borehole or in a series of boreholes in close proximity (10 feet or less) to each other. The test hole may be converted to the permanent monitor well. Log test holes in accordance with paragraph BOREHOLE LOGS, and if temporary casing is used, use in accordance with paragraph DECONTAMINATION.

3.2.3 Borehole Diameter and Depth

Provide sufficient diameter in borings for monitoring well installation to allow at least 2 inches of annular space between the borehole wall and all sides of the centered riser pipe and screen. Determine depths of individual borings as specified in the approved Monitoring Well Installation Plan, with actual depth adequate to allow for the collection of representative ground water samples for chemical analysis at the time of initial sampling.

3.2.4 Screen, Well Casing And Riser Pipe Placement

Locate well screens as indicated. Ensure the length of the screen is as indicated. Distribute slotted openings uniformly around the circumference of the screen. Ensure the open areas approach the formation's natural porosity.

Ensure personnel wear clean cotton or surgical gloves while handling the assembly. Ensure well casings, screens, plugs, and caps are decontaminated prior to delivery by the manufacturer and certified clean. Deliver, store, and handle materials in such a manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation.

a. Provide the monitoring well screen in length as determined by the Contractor and approved by the Government, with specified bottom cap securely attached, set to the appropriate depth.

b. Place the bottom of the well screen no more than 3 feet above the bottom of the drilled borehole.

c. Clean the screen and well casing and riser pipe with high pressure hot water/steam just prior to installation; allowing no foreign material to remain on the screen and well casing before installation. The use of factory-sealed (plastic wrapped) screen, free from painted markings, does not waive requirements for pre-installation cleaning. Place the well screen as specified by the geologist in charge. Ensure the well casing and riser pipe extends upwards from the screen to an elevation appropriate for the surface completion described in paragraph PROTECTIVE COVER PLACEMENT. Do not allow the well screen and riser pipe to drop or fall uncontrolled into the borehole.

d. Join the screen and well casing and riser pipe sections by flush threaded watertight joints and fastenings. Solvent glue or set screws are not permitted.

e. Use centralizers to ensure that the well screen and casing assembly is installed concentrically in the borehole. Center and plumb the well by the use of stainless steel centralizers, spaced at intervals not exceeding 40 feet along the length of the casing. Do not place centralizers on the screened interval or within the bentonite seal. Verify the alignment of the well by passing a 5 foot long section of rigid pipe ¼ inch smaller in diameter than the inside diameter of the casing through the entire well. If the pipe does not pass freely, the well is not accepted. Thoroughly clean the pipe section with high pressure hot water prior to each test. Use temporary casing, hollow stem augers or other measures, as necessary, to prevent collapse of the boring against the well screen and well casing and riser pipe prior to placement of the filter pack and sealing materials. Install a cap on the top of the riser pipe, either vented, or a telescopic fit, constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions. Make cap secure enough to preclude the introduction of foreign material into the well, yet allow pressure equalization between the well and the atmosphere.

When the assembly has been installed at the appropriate elevation, adequately secure the assembly to preclude movement during placement of the filter packs and annular seals. Cap the top of the well casing during filter pack placement.

3.2.5 Filter Pack Placement

Protect filter pack material from contamination prior to placement by either storing it in plastic lined bags, or in a location protected from the weather and contamination on plastic sheeting. Transport filter pack material to the well site in a manner which prevents contamination by other soils, oils, grease, and other chemicals.

Prior to commencement of work, receive approval from the Contractor/Buyer for equipment and methods required to place filters. Place primary and secondary filter packs as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Place both the primary and secondary filters with a tremie pipe in accordance with EPA 600-4-89-034 and ASTM D5092. Placement of the primary and secondary filters by gravity or free fall methods is not allowed. Control speed of filter placement to prevent bridging and to allow for settlement. Take frequent measurements inside the annulus during tremie pipe retraction to ensure that the filter pack is properly placed.

Dumping filter pack material from the surface of the ground and agitating the well in an effort to settle the filter material is not allowed. Install the filter pack continuously and without interruption until the filter pack has been placed to a minimum of 5 feet above the top of the screen in the monitoring well. Directly measure the depth to the top of the filter pack and record. Obtain any additional water required to be added to the filter pack material in accordance with paragraph WATER SOURCE.

3.2.6 Bentonite Seal

3.2.6.1 Bentonite Pellets

Pouring of pellets is acceptable in shallow boreholes less than 40 feet. To provide accurate measurement of bentonite pellet thickness in the well boring, tamp the pellet seal during measurement. If not placed in lifts, allow the seal a minimum hydration time of three hours, unless the manufacturer recommends a longer hydration time.

3.2.6.2 Bentonite Chips

Adequate annular space is required in the use of bentonite chips to reduce the risk of bridging. Chips are preferable to use over pellets when installing a seal in a deep water column. To provide accurate measurement of bentonite chip seal thickness in the well boring, tamp the seal during measurement. If not placed in lifts, allow the seal a minimum hydration time double the hydration time for pellets.

3.2.6.3 Bentonite Slurry

A bentonite slurry seal can be used when the seal location is too deep for the use of pellets or chips, or within a narrow borehole annulus. The slurry is made from granular or powder sodium bentonite. The specific gravity of cement grout placed atop a slurry seal will be greater than the bentonite slurry. Exercise care to preclude the grout from migrating downward into the slurry.

Mix water from an approved source with granular or powder bentonite to form a thick bentonite slurry, consisting of a mixture of bentonite and the manufacturer's recommended volume of water to achieve an optimal seal. A typical slurry mix contains at least 20 percent solids by weight and has a density of 9.4 lb per gallon of water or greater.

3.2.6.4 Bentonite Seal Thickness And Replacement

Place a minimum 5 foot thick hydrated bentonite seal on top of the filter pack. Control speed of bentonite placement to prevent bridging of pellets or chips, or segregation of slurry. Place bentonite chips and pellets in lifts of 6 inches to 1 foot with each lift allowed to hydrate for a minimum of 30 minutes prior to placing the next lift. If not placed in lifts, the minimum hydration time for pellets is 3 hours, unless manufacturer recommendations for hydration are longer. The hydration time for chips can require twice the time required for pellets. Directly measure the depth to the top of the bentonite seal and record immediately after placement, without allowance for swelling. Add water to the annular space as directed by the geologist in charge to ensure complete hydration of the bentonite. If the bentonite seal is located above any borehole fluid levels, place a 1 foot layer of fine sand at the top of the bentonite seal.

3.2.7 Grout Placement

Mechanically mix a cement bentonite grout, and place in one continuous operation into the annulus above the bentonite seal to within 5 feet of the ground surface. Make grout injection in accordance with ASTM D5092.

Place cement grout in the annular space above the bentonite seal as indicated on the well construction drawings. Place the cement grout as a slurry through a tremie pipe, and inject from the bottom up. For deep wells, inject grout in lifts to ensure that the casing is not damaged. Cure grout a minimum of 48 hours before beginning well development operations.

Add additional grout from the surface to maintain the level of the grout at the land surface as settlement occurs. Work is not permitted in the well within 48 hours after cement grouting.

Thoroughly clean the tremie pipe with high pressure hot water/steam before use in each well.

3.3 FIELD QUALITY CONTROL

3.3.1 Temporary Containment of Soil Removed from the Borehole

Stockpile soil in roll-off bins suitable for transporting contaminated soils as specified herein.

3.3.2 Well Alignment

For wells deeper than 200 feet, verify that the well is plumb.

3.3.3 Sampling

Obtain soil samples in accordance the QAPP.

Record boring information in accordance with ASTM D2487 and ASTM D2488. Indicate groundwater elevation in the log.

3.3.4 Sampling for Chemical Analysis

Include sampling requirements for obtaining and preserving samples for chemical analysis in the QAPP.

3.3.6 In-Situ Permeability Determination

Determine the in-situ permeability for each well following development but no sooner than 48 hours after development. After the well is developed and allowed to equilibrate for at least 24 hours, and before in-situ permeability testing, measure and record the static water level in the well. Determine, for each well installed, the in-situ permeability of the screened formation using an appropriate method after the well has been developed. State proposed details of the methods expected to be used and references for those methods in the Well Installation Plan. Except for formation water from the well, do not introduce any other water or liquid into the well.

3.3.7 Well Development

Within 7 days of completion of each well, but no sooner than 48 hours after cement grouting is completed, develop the well. Perform development using only mechanical surging or over pumping or a combination thereof in accordance with ASTM D5521/D5521M. Include details of the proposed development method in the Well Installation Plan. Maintain a well development record in accordance with paragraph WELL DEVELOPMENT RECORDS. Development is complete when:

a. Well water is clear to the unaided eye,

b. Sediment thickness in the well is less than 1 percent of the screen length,

c. A minimum of ten times the standing water volume in the well plus three times the volume of all added water and drilling fluid lost during drilling and installation of the well is removed, and

d. Stabilization has occurred for the following parameters: temperature, specific conductivity, pH, and turbidity readings, measured before, at least ten times during, and after development operations. Stabilization means variation of less than 0.2 pH units, variation of plus or minus 1 degree Celsius, plus or minus 10 percent change in specific conductance, and turbidity less than 5 Nephelometric Turbidity Unit (NTU), measured between three consecutive readings with one casing volume of water removed between each reading]. Conduct temperature, specific conductance, turbidity, and pH readings in accordance with EPA 600/4-79/020. At completion of well development, collect approximately 1 pint of well water in a clear glass jar. Label the jar with project name, well number and date; and digitally photograph. Suitably backlight the subject in the photograph close-up to show the clarity of the water and any suspended sediment. The photograph is a part of the well development record. Contain water removed during development and testing operations in D.O.T. approved drums, containers or vessels and dispose of by treatment at the

Operable Unit 2 Groundwater Treatment Plant or the Sites 2 and 12 Groundwater Treatment Plant, in accordance with paragraph CONTAINERIZATION OF DEVELOPMENT WATER, AND DRILL CUTTINGS, and DRILLING WASTE DISPOSAL.

3.3.7.1 Well Development Records

Prepare and submit a monitoring well development record for each monitoring well installed under the supervision of the geologist present during well installation operations, within 45 working days of the completion of development. Include the following information on the well development record, but do not limit to the following:

a. Date, time, and elevation of water level in the well before development.

b. Depth to bottom of well, name of project and site, well identification number, and date of development.

c. Method used for development, to include size, type and make of equipment, bailer, and/or pump used during development.

d. Time spent developing the well by each method, to include typical pumping rate, if pump is used in development.

e. Volume and physical character of water removed, to include changes during development in clarity, color, particulates, and odor.

f. Volume of water added to the well, if any.

g. Source of any water added to the well.

h. Volume and physical character of sediment removed, to include changes during development in color, and odor.

i. Clarity of water before, during, and after development. NTU measurements.

j. Total depth of well from top of the casing and the static water level, immediately after pumping/development, and 24 consecutive hours after development.

k. Readings of pH, specific conductance, and temperature taken before, during, and after development.

l. Name and job title of individual developing well.

m. Name and/or description of the disposal facility, for the waters removed during development.

3.3.8 Surveys

Establish coordinates and elevations for each monitoring well/test hole. Determine horizontal coordinates to the closest 1.0 foot and referenced to the State Plane Coordinate System, or Universal Transverse Mercator (UTM). If the State Plane Coordinate System/UTM is not readily available, use an existing local grid system. Obtain a ground elevation to the closest 0.1 foot at each well. The highest point on the top of the riser pipe serves as a measurement point; reference this elevation and survey to the nearest 0.01 foot using the National Geodetic Vertical Datum of 1929. If the datum is not readily available, use the existing local vertical datum. Plot the location, identification, coordinates, and elevations of the well and monuments on maps by a registered land surveyor licensed in the State of CA, with a scale large enough to show their location with reference to other structures. Submit this data with a well location map as the Installation Survey Report.

3.3.8.1 Survey Maps and Notes

Prepare and submit a tabulated list of all monitoring wells and monuments, copies of all field books, maps showing the locations, and elevations of all monitoring wells, and all computation sheets, consisting of the designated number of the well or monument, the X and Y coordinates, and all the required elevations within 45 working days after completion of the survey.

3.3.9 Project Photographs

Submit digital photographs taken before, during, and after completion of the work, of each well installation site. Also take photographs of any rock that is cored at the site; take a minimum of one view of each well installation. Document the following information:

Project No. Contract No. Contractor/Photographer:

Photograph No. Date/Time:

Description:

Direction of View:

3.4 ADJUSTING AND CLEANING

3.4.1 Site Cleanup

After completion of the work, remove tools, appliances, surplus materials, temporary drainage, rubbish, and debris incidental to work. Backfill excavation and vehicular ruts and dress to conform with the existing landscape or terrain. Repair or replace utilities, structures, roads, fences, or any other pre-existing item damaged due to negligence. Accomplish repair or replacement prior to completion of this contract.

3.4.2 Water From Well Development Operations

Water generated during well installation will be containerized and treated at the Operable Unit 2 Groundwater Treatment Plant or the Site 2 and 12 Groundwater Treatment Plant.

]3.4.3 Drilling Waste Disposal

Dispose of slurry, drill cuttings, rock core; other solid or liquid material bailed, pumped, or otherwise removed from the borehole during drilling, installation, completion, and well development procedures; and fluids from material/equipment decontamination activities per the QAPP.

3.4.4 Transportation Of Contaminated Soil And Water

Comply with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and bear responsibility and cost for any noncompliance. In addition to those requirements, do the following:

a. Inspect and document vehicles and containers for proper operation and covering.

b. Inspect vehicles and containers for proper markings, and other requirements for waste shipment.

c. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.

3.4.5 Disposal of Contaminated Soil And Water

Dispose contaminated materials removed from the site in accordance with the QAPP.

3.5 CLOSEOUT ACTIVITIES

3.5.1 Well Acceptance

Properly construct, install, develop, and test all wells according to the requirements of this specification so that they are suitable for the intended purpose. If installed wells are not functional or not in accordance with these specifications, the Contractor/Buyer will disapprove the well and direct repair or replacement, and instruct abandonment of the disapproved well.

3.5.2 Documentation Reports

Submit reports for well construction and development. Establish and maintain documentation reports for well construction and development to record the desired information and to assure compliance with contract requirements, including, but not limited to: borehole logs, well construction diagrams, well development record, and analytical results for well and investigation-derived waste samples.

3.5.2.1 Borehole Logs

Submit original borehole logs, within 45 working days after completion of the boring and well installation procedures. Prepare and complete a borehole log for each boring drilled, prepared by the geologist present onsite during all well drilling and installation activities. Keep copies current and complete all well logs in the field at each well site and make available at all times for inspection by the Government. Include, as a minimum, the following:

a. Name of the project and site.

b. Boring/well identification number.

c. Location of boring (coordinates, if available).

d. Make and manufacturer's model designation of drilling equipment and name of drilling firm.

e. Date boring was drilled.

f. Reference data for all depth measurements.

g. Name of driller and name and signature of geologist preparing log.

h. Nominal hole diameter and depth at which hole diameter changes.

i. Total depth of boring.

j. Method of drilling, including information such as rod size, bit type, pump type, etc. Also include a description of any temporary casing used, drill fluids and fluid additives used, if any, including brand name and amount used, along with the reason for and start (by depth) of its use, and, if measured, mud viscosities and weight.

k. Depth of each change of stratum. If location of strata change is approximate, so state in the report.

l. Description of the material of which each stratum is composed, in accordance with ASTM D2488 and/or standard rock nomenclature, as necessary. Include in soil parameters for logging, but do not limit to: classification, depositional environment and formation, if known, Unified Soil Classification Symbol, secondary components and estimated percentages, color (using FSUP 77341 or GSA RCC00100R), plasticity, consistency (cohesive soil), density (non-cohesive soil), moisture content, structure and orientation, and grain angularity.

m. Note and record the results of visual observation of the material encountered, and any unusual odor detected.

n. Depth of any observed fractures, with strike and dip, weathered zones, or any abnormalities encountered.

o. Depth and estimated percent of drill fluid loss or lost circulation. Measures taken to regain drill water circulation. Significant color changes in the drilling fluid return.

3.5.2.2 Installation Diagrams

Submit as-built installation diagram for each monitoring well installed within 45 working days of the completion of the installation, prepared by the geologist present during well installation operations. The well will not be accepted by the Government before the geologic logs and installation diagrams are received. Clearly illustrate in the diagram the as-built condition of the well and include, but do not limit to the following items:

a. Name of the project and site.

b. Well identification number.

c. Name of driller and name and signature of the geologist preparing diagram.

d. Date of well installation.

e. Description of material from which the well is constructed, including well casing and riser pipe and screen material, centralizer composition, if used, diameter and schedule of casing and screen, gradation of filter pack, lithologic description, brand name (if any), source, and processing method, and method of placement of the filter pack, bentonite seal type (pellets, granules, chips, or slurry), grout type (cement or high-solids bentonite) and type of protective cover (protective casing or flush-to-ground).

f. Total depth of well.

g. Nominal hole diameter.

h. Depth to top and bottom of screen, and filter pack.

i. Depth to top and bottom of any seals installed in the well boring (grout or bentonite).

j. Type of cement and/or bentonite used, mix ratios of grout, method of placement and quantities used.

k. Elevations/depths/heights of key features of the well, such as top of well casing and riser pipe, top and bottom of protective casing, ground surface, the depth of maximum frost penetration (frost line), bottom of well screen, top and bottom of filter pack, and top and bottom of seal.

l. Other pertinent construction details, such as slot size and percent open area of screen, type of screen, and manufacturer of screen.

m. Well location by coordinates. Include a plan sheet showing the coordinate system used and the location of each well. A plan sheet is not required for each well installation diagram; multiple wells may be shown on the same sheet.

n. Static water level upon completion of the well.

o. Special problems and their resolutions; e.g., grout in wells, lost casing, or screens, bridging, etc.

p. Description of surface completion.

-- End of Section --

SECTION 40 60 00: PROCESS CONTROL
05/20

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering
ANSI INCITS 154	(1988; R 2004) Office Machines and Supplies - Alphanumeric Machines - Keyboard Arrangement

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.8	(2022; Supplement 2022) Gas Transmission and Distribution Piping Systems
ASME BPVC SEC VIII	(2010) Boiler and Pressure Vessel Codes: Section VIII Rules for Construction of Pressure Vessel

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2022) Grooved and Shouldered Joints ASTM

INTERNATIONAL (ASTM)

ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM D635	(2018) Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D2000	(2018) Standard Classification System for Rubber Products in Automotive Applications INSTITUTE OF ELECTRICAL AND ELECTRONICS

	ENGINEERS (IEEE)
IEEE 142	(2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60584-1	(2013) Thermocouples - Part 1: EMF Specifications and Tolerances
IEC 61131-3	(2013) Programmable Controllers - Part 3: Programming Languages

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air
ISA 92.00.01	(2010; R 2015) Performance Requirements for Toxic Gas Detectors
ISA 101.01	(2015) Human Machine Interfaces for Process Automation Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA ICS 2	(2000; R 2020) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 3	(2005; R 2010) Medium-Voltage Controllers Rated 2001 to 7200 V AC
NEMA ICS 4	(2015) Application Guideline for Terminal Blocks
NEMA ICS 5	(2017) Industrial Control and Systems: Control Circuit and Pilot Devices

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 79	(2015) Electrical Standard for Industrial Machinery

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST SP 250	(1991) Calibration Services Users Guide

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 60	Standards of Performance for New Stationary Sources
47 CFR 15	Radio Frequency Devices UNDERWRITERS

LABORATORIES (UL)

UL 94	(2023; Reprint May 2023) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 508A	(2018; Reprint Jul 2022) UL Standard for Safety Industrial Control Panels
UL 1059	(2019; Reprint Jul 2022) UL Standard for Safety Terminal Blocks

1.2 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Contractor Design Drawings; Draft As-Built Drawings;

SD-03 Product Data Control Drawings Sensors and Meters

Performance Verification Test (PVT) Factory Test Procedure

SD-06 Test Reports Factory Test Report

Testing, Adjusting and Commissioning Performance Verification

Test(PVT) Endurance Test

SD-07 Certificates

Control and Sensor Wiring Ground Rods

Wiring Installation

SD-10 Operation and Maintenance Data Training Manual; Control System;

SD-11 Closeout Submittals Final As-Built Drawings;

1.3 SITE ENVIRONMENTAL CONDITIONS

The expected site environmental conditions are a minimum of [54] degrees F and a maximum of [67] degrees F.

1.4 SEQUENCING

TABLE I: PROJECT SEQUENCING specifies the sequencing of submittals as specified in paragraph SUBMITTALS (denoted by an 'S' in the 'TYPE' column) and activities as specified in PART 3 EXECUTION (denoted by an 'E' in the 'TYPE' column).

1.5.1 Sequencing for Submittals

The sequencing specified for submittals is the deadline by which the submittal must be initially submitted to the Contractor/Buyer. Following submission there will be a Contractor/Buyer review period as specified in Section 01 33 00 SUBMITTAL PROCEDURES. If the submittal is not accepted by the Contractor/Buyer, revise the submittal and resubmit it to the Government within 14 calendar days of notification that the submittal has been rejected. Upon re-submittal there will be an additional Contractor/Buyer review period. If the submittal is not accepted the process repeats until the submittal is accepted by the Contractor/Buyer.

1.5.2 Sequencing for Activities

The sequencing specified for activities indicates the earliest the activity may begin.

1.5.3 Abbreviations

In TABLE I the abbreviation AAO is used for 'after approval of' and 'ACO' is used for 'after completion of'.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The process control system must be used to monitor and control the operation of process equipment as specified and in accordance with the sequence of operation and control schematics shown on the drawings. The process control system must provide for operator interaction, overall process control system supervision, and process equipment control and monitoring. Provide hardware configured and sized to support expansion as specified and shown on the drawings.

The process control system must be complete including sensors, field preamplifiers, signal conditioners, offset and span adjustments, amplifiers, transducers, transmitters, control devices, engineering units conversions and algorithms for the applications; and must maintain the specified end-to-end process control loop accuracy from the sensor to display and final control element. Connecting conductors must be suitable for installed controls. Enclosers must be rated for NEMA 4.

2.1.1 Operation

The process control system provided under this specification must operate using a combination of sequential function charts, function block diagrams, structured text, instruction, and ladder logic type as defined in IEC 61131-3 and supervisory control to provide the required sequences of operation. Input data to the controller must be obtained by using instruments and controls interfaced to mechanical, electrical, utility systems and other systems as shown and specified. All required setpoints, settings, alarm limits, and sequences of operation must be as identified [in the database/ settings tables] [and] [or] [sequences of operation indicated].

2.1.2 Points

Provide inputs to and outputs from the process control system in accordance with the Input/Output (I/O) Summary Table indicated. Each connected analog output (AO), analog input (AI), binary output (BO), binary input (BI), pulse accumulator (PA) input and other input or output device connected to the control system must represent a "point" where referred to in this specification.

2.1.3 System Reliability

The system must be designed for maximum reliability, safety and integrity while maintaining an availability of [99.99%] or better.

2.2 MATERIALS AND EQUIPMENT

2.2.1 Product Certifications

Computing devices, as defined in FCC Part 15, supplied as part of the process control system must be certified to comply with the requirements of Class B computing devices.

2.2.2 Standard Products

Materials and equipment must be standard unmodified products of a manufacturer regularly engaged in the manufacturing of such products. Units of the same type of equipment must be products of a single manufacturer. Items of the same type and purpose must be identical and supplied by the same manufacturer, unless replaced by a new version approved by the Contractor/Buyer.

2.2.3 Nameplates

Each major component of equipment must have the manufacturer's name and address, and the model and serial number in a conspicuous place. Laminated plastic nameplates must be provided for equipment devices and panels furnished. Each nameplate must identify the device, such as pump "P-1" or valve "VLV-402". Labels must be coordinated with the schedules and the process and instrumentation drawings. Laminated plastic must be 1/8 inch thick, white with black center core. Nameplates must be a minimum of 1 by 3 inches with minimum ¼ inch high engraved block lettering. Nameplates for devices smaller than 1 by 3 inches must be attached by a nonferrous metal chain. All other nameplates must be attached to the device.

2.3 GENERAL REQUIREMENTS

Equipment located outdoors, not provided with climate controlled enclosure, must be capable of operating in the ambient temperature range. Equipment and wiring must be in accordance with NFPA 70, with proper consideration given to environmental conditions such as moisture, dirt, corrosive agents, and hazardous area classification.

2.4 SENSORS

2.4.1 Transmitter

Unless indicated otherwise, each sensor must be provided with a transmitter, selected to match the sensor. Except where specifically indicated otherwise on the drawings, the transmitter must be provided with a four digit or analog visual display of the measured parameter and with a [4 to 20 mAdc] [binary] [0-10 vdc] [________________] output signal proportional to the level of the measured parameter. Accuracy must be plus or minus [0.5] [1] [2] [5] [_____] percent of full scale reading with output error not exceeding plus or minus [0.25] [0.5] [_____] percent of [the calibrated measurement] [full scale]. Transmitter must be located where indicated, mounted integrally with the sensor, pipe mounted, wall mounted or installed in the control panel. The distance between the sensor and transmitter must not exceed the manufacturer's recommendation. Field preamplifiers and signal conditioners must be included when necessary to maintain the accuracy from sensor to the programmable logic controller or recorder.

2.4.2 Flow Rate Sensors and Meters

Liquid flow indication must be provided in [gpm]. Pressure taps must incorporate appropriate snubbers. Unless indicated otherwise, the flow transmitter must produce a signal that is proportional to the volumetric flow rate, compensated for fluid temperature, and must have an accuracy of plus or minus [1] [3] [_________________] percent of [full flow] [the actual flow]. Flow transmitter must be located within [15 feet] of the flow element. The flow transmitter must include a [digital] [______] readout of the volumetric flow rate to [3] [_____] significant figures. [The controller must be provided with a minimum of three alarm lights. The first alarm light must indicate when the lower (warning) detection level has been exceeded. The second alarm light must indicate when the upper (alarm) detection level has been exceeded. The third alarm light must indicate a controller malfunction, including loss of power or loss of sensor input.] [The controller must be provided with a minimum of three sets of dry contacts rated in accordance with NEMA ICS 1. The first set of contacts must close when the lower (warning) detection level has been exceeded. The second set of contacts must close when the upper (alarm) detection level has been exceeded. The third set of contacts must close when a controller malfunction has occurred, including loss of power or loss of sensor input.] The alarm levels must be individually adjustable. The controller must be provided with an audible warning horn that sounds when the upper detection level has been exceeded, and a warning horn silence button. The controller must provide a [4-20 mAdc] [________] output signal to the programmable logic controller, proportional to the measured parameter. The controller must be provided with an internal battery to maintain operation for a minimum of 12 hours if power is lost. Flow rate must be controlled to within plus or minus [5] [_________] percent of the design flow.

2.4.2.1 Magnetic Flowmeter

Magnetic flowmeter must be [non-intrusive,] DC pulse type and must measure fluid flow through the use of a self-generated magnetic field. The meter must have automatic zeroing circuitry. The magnetic flow element must be encapsulated in [type 300 stainless steel] [or] [anodized aluminum]. Flowmeter must be capable of measuring up to a maximum flow velocity of [10] [____] fps. The metering tube must be constructed of [316 stainless steel] [anodized aluminum] [_____]. The meter must be rated for a process temperature range of [32 to 212 F] and [0 to 149F] ambient. The maximum pressure drop across the meter and appurtenances must be 5 psi at the maximum flow rate.

2.4.2.2 Leak Detection

Double walled containment system leak detectors must use electrodes mounted in the interstices of double walled containment systems with a minimum time delay of [0.5] [_____] seconds.

2.4.3 Pressure Instrumentation

Pressure taps must incorporate appropriate snubbers.

2.4.3.1 Pressure Switch

Sensors must be [diaphragm] [Bourdon tube] [solid state] and must be constructed of [brass] [316 stainless steel] [_____]. Pressure switch must have a repetitive accuracy of plus or minus [5.0] [____________] percent of the operating range and must withstand up to [150] [__] percent of rated pressure.

Switch actuation set point must be adjustable over the operating pressure range with a differential adjustment span of [20] [_____] to [40] [_____] percent of the range of the switch. The switch must have Form C snap-action contacts rated in accordance with NEMA ICS 1.

2.5 PROGRAMMABLE LOGIC CONTROLLER (PLC)

2.5.1 PLC General Requirements

PLCs must be micro-processor based, capable of receiving binary and analog inputs and, through programming, must be able to control binary and analog output functions, perform data handling operations and communicate with external devices. PLCs must meet the requirements of Class A computing devices, and must be labeled as set forth in 47 CFR 15 and must be able to withstand conducted susceptibility test as outlined in NEMA ICS 1, NEMA ICS 2, NEMA ICS 3, [and] [or] IEEE C37.90.1. PLCs must function properly at temperatures between 32 and 122 degrees F at 5 to 95 percent relative humidity non-condensing and must tolerate storage temperatures between minus 40 and plus 140 degrees F at 5 to 95 percent relative humidity non-condensing.

2.5.2 Modular PLC

PLCs must be based on a modular, field expandable design allowing the system to be tailored to the process control application. The system must be expandable through the use of additional hardware and/or user software. As a minimum, the PLC must include a mounting backplane, power supply module, central processing unit (CPU) module, communications module, and input/output (I/O) module. The modules must be grouped together in a mounting rack or cabinet. The mounting rack backplane must provide the communications mechanism to fully integrate the individual modules located within the rack. Modules other than I/O modules must plug directly into the backplane. The use of wire connectors between modules will not be allowed except for expansion of the system to include multiple backplanes. The rack size must be as needed to hold the equipment necessary while performing the required control functions. [The system configuration must allow for the removal and/or installation of modules under power.]

2.5.2.1 Central Processing Unit (CPU) Module

The CPU module must be a self-contained, microprocessor based unit that provides time of day, scanning, application program execution, storage of application programs, storage of numerical values related to the application process and logic, I/O bus traffic control, peripheral and external device communications and self-diagnostics. The scan time must be [250 milliseconds] or better including spare I/O channels.

2.5.2.2 Communications Module

The communications module must allow peer-to-peer communication with other PLCs and must allow the PLC to communicate with the central station, or workstation. The communication module must utilize the manufacturer's standard communication architecture and protocol, ethernet architecture and protocol or a combination of these. The communication module must allow programming of the PLC to be done locally through the use of a laptop computer[or from the central station or remote workstation].

2.5.2.3 Power Supply Module

One or more power supply modules must be provided as necessary to power other modules installed in the same cabinet. Power supply modules must plug directly into the backplane. Auxiliary power supplies may be used to supply power to remote cabinets or modules.

a. Power supply modules must use [AC] [DC] power with a nominal voltage of [120 VAC] [220 VAC] [24 VDC] [48 VDC] [125VDC] plus or minus 5 percent. The power supply module must monitor the incoming line voltage level and must provide over current and over voltage protection. If the voltage level is detected as being out of range the power supply module must continue to provide power for an adequate amount of time to allow for a safe and orderly shutdown. Power supply modules must be capable of withstanding a power loss for a minimum of 20 milliseconds while still remaining in operation and providing adequate power to all connected modules.

b. Each power supply module must be provided with an on-off switch integral to the module. If the manufacturer's standard power supply module is not provided with an on-off switch, a miniature toggle type switch must be installed near the PLC and must be clearly labeled as to its function..

c. Provide power supply modules with an indicating light which must be lit when the module is operating properly.

2.5.2.4 Input/Output (I/O) Modules

Modules must be self-contained, microprocessor based units that provide an interface to field devices.[The modules must be located in the same cabinet as the other PLC components.] Each module must contain visual indication to display the on-off status of individual inputs or outputs. Each I/O must be protected against reversal of polarity of the signal. Analog inputs and analog outputs must have 'open, short and out of range circuit' detection. It must be configurable per channel.

2.5.3 Loop PLC

PLCs must be single or multiple loop controllers depending on the process control system requirements. Controllers must be self-contained and must include a central processing unit (CPU), program memory, power supply, input/output capability, [network communications capability] and display/keyboard. The controller must have a scalable process variable for each loop. Controller must have proportional, integral and derivative (PID) control logic. Analog outputs must be configured as direct acting or reverse acting. The controller must have keyboard, display, auto/manual selection for control of each loop output, remote setpoint, adjustment/local setpoint adjustment selection with adjustable high-end and low-end limits, ratio and bias adjustment on remote setpoint input, [operator-initiated self-tune/manual-tune selection] [and anti-reset wind-up feature]. Controller must power analog output loops to 20 mAdc when connected to a load of 600 ohms.

2.5.3.1 Central Processing Unit (CPU)

The central processing unit must be microprocessor based and must provide time of day, scanning, application program (ladder rung logic) execution, storage of application programs, storage of numerical values related to the applications process and logic, I/O bus traffic control, peripheral and external device communications and self-diagnostics.

2.5.3.2 Power Requirements

Each controller must be powered by [AC] [DC] power with a nominal voltage of [120 VAC] [220 VAC] [24 VDC] [48 VDC] [125VDC]. Power consumption must not exceed 25 watts. Controller must provide electrical noise isolation between the AC power line and the process variable inputs, remote setpoint inputs and output signals of not less than 100 dB at 60 Hertz common mode rejection ration and not less than 60 dB at 60 hertz normal-mode rejection ration.

2.5.3.3 On-Off Switch

Each controller must be provided with an integral on-off switch. If the controller is not provided with a manufacturers standard on-off switch, a miniature toggle type switch must be installed near the controller and must be clearly labeled as to its function.

2.5.3.4 Parameter Input and Display

Enter and display control parameters directly, in the correct engineering units, through a series of keystrokes on a front panel display with decimal point and polarity indication. Provide display [in metric English units] [in metric or English units as selected by the operator].

[2.6.3.5 Self Tuning

Provide controllers with self-tuning operation which applies to proportional, integral and derivative modes of control and modify the mode constants as required. Self-tuning must only be in operation when selected from the front panel.

]2.6.3.6 Manual Tuning

Controllers must be provided with manual tuning operation which must apply to proportional, integral and derivative modes of control, by means of individually adjustable mode constants. These adjustments must be set for the appropriate value if a particular control mode action is required or to zero if that particular mode is not desired. The proportional mode constant must be adjustable from 0 to 200 percent of the input signal range. The integral mode constant must be adjustable from 0 to 20 repeats per minute. The derivative mode constant must be adjustable from 0 to [5] [____] minutes.

2.5.4 Program Storage/Memory Requirements

The CPU must utilize the manufacturer's standard non-volatile memory for the operating system. The controller must have electronically [readable and writeable nonvolatile memory (EPROM, EEPROM, or Flash PROM)] [battery backup volatile memory. Must be possible to change battery with power on] for storage of user programs. The user programs must be loaded through the controller keypad, central station or through the use of a laptop computer. The CPU memory capacity must be based on the system's control requirements. The memory capacity must be sized such that, when the system is completely programmed and functional, no more than 50 percent of the memory allocated for these purposes is used.

2.5.5 Input/Output Characteristics

Each controller must allow for analog input, analog output, binary input and binary output. The number and type of inputs and outputs for the system must be as shown on the drawings and must comply with the sequence of control. The system capacity must include a minimum of 20 percent spare input and output points (no less than two points) for each point type provided. During normal operation, a malfunction in any input/output channel must affect the operation of that channel only and must not affect the operation of the CPU or any other channel. All input circuits must have a minimum optical isolation of 1500 VRMS and must be filtered to guard against high voltage transients from the externally connected devices. All output circuits must have a minimum optical isolation of 1500 VRMS and must be filtered to guard against high voltage transients from the externally connected devices.

2.5.5.1 Analog Inputs

Analog input circuits must be available in [+/-10V] [+/-5V] [0-10V] [0-5V] [4-20 mA].

2.5.5.2 Binary Inputs

Binary input circuits must be available in [5 volt TTL] [10-30 VDC] [18-26 VDC] [79-132VDC] [79-132 VAC].

2.5.5.3 Analog Outputs

Analog output circuits must be available in [+/-10V] [4-20 mA].

2.5.5.4 Binary Outputs

Binary output circuits must be available in [5 volt TTL] [10-30 VDC] [18-26 VDC] [79-132 VAC].

2.5.5.5 Pulse Inputs

Pulse inputs must be able to detect a pulse of [x milliseconds] or less.

2.5.6 Wiring Connections

Wiring connections must be heavy duty, self-lifting, pressure type screw terminals to provide easy wire insertion and secure connections. The terminals must accept two #14 AWG wires. A hinged protective cover must be provided over the wiring connections. The cover must have write-on areas for identification of the external circuits.

2.5.7 On-Off Switch

Each controller must be provided with an integral on-off power switch. If the controller is not provided with a manufacturer's standard on-off switch, a miniature toggle type switch must be installed in the control panel near the controller and must be clearly labeled as to its function.

2.5.8 Diagnostics

Each PLC must have diagnostic routines implemented in firmware. The CPU must continuously perform self-diagnostic routines that will provide information on the configuration and status of the CPU, memory, communications and input/output. The diagnostic routines must be regularly performed during normal system operation. A portion of the scan time of the controller must be dedicated to performing these housekeeping functions. In addition, a more extensive diagnostic routine must be performed at power up and during normal system shutdown. The CPU must log input/output and system faults in fault tables which must be accessible for display. When a fault affects input/output or communications modules the CPU must shut down only the hardware affected and continue operation by utilizing the healthy system components. All faults must be annunciated at [the PLC] [and] [the central station]. Diagnostic software must be useable in conjunction with the portable tester. The following diagnostics must be performed:

a. Analog Inputs: Sensor out of range, open or shorted loop, analog-to-digital converter check

b. Analog Outputs: Open or shorted loop

c. Configuration: Check compatibility and availability of selected I/O hardware and software

d. Memory: Checksum, parity check End-to End CPU memory

2.5.9 Accuracy

Provide controllers with an accuracy of plus or minus [0.25] percent of input span.

[2.6.10 Primary/Secondary PLC

The Primary/Secondary PLCs must have redundancy built into the process control system by having two systems (power supply and CPU) either of which is capable of controlling the system. Data must be transferred from the primary processor to the secondary processor each logic cycle. [The I/O scan must be transferred from the PLC currently in charge to the other at the end of each logic execution and the logic must be executed.] [The data must be transferred via asynchronous transfer where the primary processor haws two separate microprocessors embedded in its circuitry and at the end of logic execution all data must be passed to the second microprocessor and the second microprocessor must handle all transfer tasks while the first executes the next program scan.] The Primary must perform the execution of the outputs unless a fault is detected, in which case execution of the outputs is performed by the Secondary. Switchover must be automatic and indication of the switchover must be displayed on the Central Operator Workstation.

2.7 PLC SOFTWARE

Furnish all PLC software described in this specification as part of the complete control system.

2.7.1 Operating System

Each PLC must be provided with the manufacturer's standard operating system software package. The PLC must maintain a point database in its memory that includes all parameters, constraints and the latest value or status of all points connected to the PLC. Execution of the PLC application programs must use the data in memory resident files. The operating system must support a full complement of process control functions. It must be possible to define these functions using a mix of ladder logic diagrams, function blocks, sequential function charts and text programming.
Programming methods and interactions must be based on IEC 61131-3. A combination of the programming methods must be possible within a single controller. The operating system must allow loading of control logic locally [or from the central station in which case it must require a password to do so] and data files from the portable tester. It must also support data entry and diagnostics using an operator interface panel attached directly to the PLC. Each PLC must be capable of operating in standalone mode.

2.7.1.1 Startup

The PLC must have startup software that causes automatic commencement of operation without human intervention, including startup of all connected I/O functions. A PLC restart program based on detection of power failure at the PLC must be included in the PLC software. The restart program must include start time delays between successive commands to prevent demand surges or overload trips.

2.7.1.2 Failure Mode

Upon failure for any reason, each PLC must perform an orderly shutdown. Systems which are not Primary/Secondary must force all PLC outputs to a predetermined (failure mode) state, consistent with the failure modes shown and the associated control device. Primary/Secondary systems must transfer I/O scan and control to the PLC not currently failed.

2.7.2 Functions

The controller operating system must be able to scan inputs, control outputs, and read and write to its internal memory in order to perform the required control as indicated in the sequence of control on the drawings. The controller must periodically perform self-diagnostics to verify that it is functioning properly. [If the system is set up as a Primary/Secondary system the system must attempt to switch to the other PLC upon sensing a fault in the currently controlling PLC.]

2.7.2.1 Analog Monitoring

Measure and transmit all analog values including calculated analog points.

2.7.2.2 Logic (Virtual)

Logic (virtual) points must be software points entered in the point database which are not directly associated with a physical I/O function. Logic (virtual) points must be analog or binary points created by calculation from any combination of binary and analog points, or other data having all the properties of real points, including alarms, without the associated hardware. Logic (virtual) points must be defined or calculated and entered into the database. The calculated analog point must have point identification in the same format as any other analog point.

2.7.2.3 State Variables

If an analog point represents more than two (up to 8) specific states, each state must be nameable. For example, a level sensor must be displayed at its measured engineering units plus a state variable with named states usable in programs or for display such as low alarm/low/normal/high/high alarm.

2.7.2.4 Analog Totalization

Any analog point must be operator assignable to the totalization program. Up to eight analog values must be totalized within a selectable time period.

2.7.3 Alarm Processing

Each PLC must have alarm processing software for AI, DI, and PA alarms for all real and virtual points connected to that PLC.

2.7.3.1 Binary Alarms

Binary alarms are those abnormal conditions indicated by BIs as specified and shown. The system must automatically suppress analog alarm reporting associated with a binary point when that point is turned off.

2.7.3.2 Analog Alarms

Analog alarms are those conditions higher or lower than a defined value, as measured by an AI. Analog readings must be compared to predefined high and low limits, and alarmed each time a value enters or returns from a limit condition. Unique high and low limits must be assigned to each analog point in the system. In control point adjustment (CPA) applications, key the limit to a finite deviation traveling with the setpoint. The system must automatically suppress analog alarm reporting associated with an analog point when that analog point is turned off.

2.7.3.3 Pulse Accumulator (PA) Alarms

Pulse accumulator alarms are those conditions calculated from totalized values of accumulator inputs or PA input rates that are outside defined limits as specified and shown. PA totalized values must be compared to predefined limits and alarmed each time a value enters a limit condition. Unique limits must be assigned to each PA point in the system.

2.7.4 Constraints

2.7.4.1 Equipment Constraints Definitions

Each control point in the database must have PLC resident constraints defined and entered by the Subcontractor, including as applicable: maximum starts (cycles) per hour; minimum off time; minimum on time; high limit (value in engineering units); and low limit (value in engineering units).

2.7.4.2 Constraints Checks

All control devices connected to the system must have the PLC constraints checked and passed before each command is issued. Each command point must have unique constraints assigned. High and low "reasonableness" values or one differential "rate-of-change" value must be assigned to each AI. Each individual point must be capable of being selectively disabled by the operator from the central station.

2.7.5 Control Sequences and Control Loops

Specific functions to be implemented are defined in individual system control sequences and database tables shown on the drawings, and must include, as applicable, the following functions: PI control must provide proportional control and proportional plus integral control; two position control must provide control for a two state device by comparing a set point against a process variable and an established dead band; floating point control must exercise control when an error signal exceeds a selected dead band, and must maintain control until the error is within the dead band limits; signal selection must allow the selection of the highest or lowest analog value from a group of analog values as the basis of control and must include the ability to cascade analog values so that large numbers of inputs can be reduced to one or two outputs; signal averaging must allow the mathematical calculation of the average analog value from a group of analog values as the basis of control and must include the ability to "weight" the individual analog values so that the function output can be biased as necessary to achieve proper control; reset function must develop an AO based on up to two AIs and one operator specified reset schedule.

2.7.6 Command Priorities

A scheme of priority levels must be provided to prevent interaction of a command of low priority with a command of higher priority. Override commands entered by the operator must have higher priority than those emanating from applications programs.

2.7.7 Resident Application Software

Provide resident applications programs developed in accordance with paragraph GRAPHICAL PROGRAMMING to achieve the sequences of operation, parameters, constraints, and interlocks necessary to provide control of the process systems connected to the process control system. All application programs must be resident in the PLC and must execute in the PLC, and must coordinate with each other, to ensure that no conflicts or contentions remain unresolved.

2.7.7.1 Program Inputs and Outputs

Use program inputs listed for each application program to calculate the required program outputs. Where specific program inputs are not available, a "default" value or virtual point appropriate for the equipment being controlled and the proposed sequence of operation must be provided to replace the missing input, thus allowing the application program to operate.

2.7.7.2 Failure Mode

In the event of a PLC failure, the controlled equipment must continue to function in the failure mode shown on the drawings. Systems that are Primary/Secondary must transfer control to the non-failed system.

2.8 CONTROL PANELS

2.8.1 Components

2.8.1.1 Enclosures

The enclosure for each control panel must conform to the requirements of NEMA 250 for the types specified. Finish color must be the manufacturer's standard, unless otherwise indicated. Enclosures for installation in mechanical equipment rooms must be Type [1] [4] [12]; those for installation in clean, dry indoor occupied space may be Type 1; other locations must be as otherwise specified or shown. Enclosures for equipment installed outdoors must be Type 4 or as shown. Enclosures for installation in a corrosive environment must be Type 4X and must be constructed of [stainless steel] [fiberglass] [polymer plastic]. Painted steel must not be allowed for use in a corrosive environment. Enclosure must be provided with a single, continuously hinged exterior door with print pocket, 3-point latching mechanism and key lock and a single, continuously hinged interior door.

2.8.1.2 Controllers

Provide controllers in accordance with paragraph Programmable Logic Controller (PLC).

2.8.1.3 Standard Indicator Light

Indicator lights showing on, off, stand-by, automatic, manual depending on the application must comply with NEMA ICS 1, NEMA ICS 2 and UL 508A. Lights must be heavy duty, round and must mount in a 0.875-inch mounting hole. Indicator lights must be LED type and must operate at 120 VAC or 24 VDC. Long life bulbs must be used. Indicator light must be provided with a legend plate labeled as shown on the drawings. Lens color must be as indicated on the drawings. Lights must be push to test (lamp) type.

2.8.1.4 Selector Switches

Selector switches must comply with NEMA ICS 1, NEMA ICS 2 and UL 508A. Selector switches must be heavy duty, round and must mount in a 0.875-inch mounting hole. The number of positions must be as indicated on the drawings. Switches must be [illuminated] [non-illuminated] [as indicted of the drawings]. Switches must be rated for 600 volts, 10 amperes continuous. Selector switches must be provided with a legend plate labeled as shown on the drawings. Where indicated or required, dual auxiliary contacts must be provided for the automatic position to provide position sensing at the central station or workstation. Auxiliary contacts must be rated for 120 VAC, 1A as a minimum. Where indicated on the drawings, switches must be key operated. All keys must be identical.

2.8.1.5 Push Buttons

Push buttons must comply with NEMA ICS 1, NEMA ICS 2 and UL 508A. Push buttons must be heavy duty, round and must mount in a 22.5-mm 0.875-inch mounting hole. The number and type of contacts must be as indicated on the drawings or required by the Sequence of Control. Push buttons must be rated for 600 volts, 10 amperes continuous. Push buttons must be provided with a legend plate labeled as shown on the drawings.

2.8.1.6 Relays

Relays must comply with NEMA ICS 5 and derated for altitude above 1,500 m. Relays must be [single-pole, single-throw (SPST)] [single-pole, double-throw (SPDT)] [double-pole, single throw (DPST)] [double-pole, double-throw (DPDT)] [as required by the Sequence of Control]. Relay coil must be [120 VAC] [24 VDC] and must be provided with matching mounting socket. Power consumption must not be greater than 3 watts. Coils must have a minimum current rating of [___] amps and minimum voltage rating of [___] volts. Contacts must have a minimum current rating of [ ] amps and minimum voltage rating of [___] volts.

2.8.1.7 Terminal Blocks

Terminal blocks must comply with NEMA ICS 4 and UL 1059. Terminal blocks for conductors exiting control panels must be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks must be made of bakelite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip must form part of the terminal block and each terminal must be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

2.8.1.8 Alarm Horns

Alarm horns must be provided where indicated on the drawings. Horns must be vibrating type and must comply with UL 508A. Horns must provide 100 dB at 10 feet. Exterior mounted horns must be weather proof by design or must be mounted in a weather proof enclosure that does not reduce the effectiveness of the horn.

2.8.2 Panel Assembly

Control panels must be factory assembled and shipped to the jobsite as a single unit. Panels must be fabricated as indicated and devices must be mounted as shown or required. Each panel must be fabricated as a bottom-entry connection point for process control system electrical power, [process control system main air source,] process control system wiring, [control air pneumatic tubing,] [communications system wiring to [other control panels] [operators workstation]].

2.8.3 Electrical Requirements

Each panel must be powered by a dedicated [120 volts ac] [] [125VDC] circuit, with a fuse, [10 amp] [_____________] [sized as recommended by the equipment manufacturer], and a disconnect switch located inside the panel. Wiring must terminate inside the panel on terminal blocks.

2.8.4 Power Line Conditioner

Each control panel must be provided with a power line conditioner to provide both voltage regulation and noise rejection. The power line conditioner must be of a ferro-resonant design, with no moving parts and no tap switching, while electrically isolating the secondary from the power line side. The power line conditioner must be sized for 125 percent of the actual connected kva load. Characteristics of the power line conditioner must be as follows:

2.8.4.1 85 Percent Load

At 85 percent load, the output voltage must not deviate by more than plus or minus 1 percent of nominal voltage when the input voltage fluctuates between minus 20 percent to plus 10 percent of nominal voltage.

2.8.4.2 Load Changes

During load changes of zero to full load, the output voltage must not deviate by more than plus or minus 3 percent of nominal voltage. Full correction of load switching disturbances must be accomplished within 5 cycles, and 95 percent correction must be accomplished within 2 cycles of the onset of the disturbance.

2.8.5 Grounding

Control panel enclosures must be equipped with a solid copper ground bus or equivalent. The ground bus must be securely anchored to the enclosure so as to effectively ground the entire structure. Clamp-type terminals sized large enough to carry the maximum expected current must be provided on the ground bus for grounding cables. Where a definite circuit ground is required, a single wire not less than #10 AWG must run independently to the panel ground bus and must be fastened to the ground bus with a bolted terminal lug. Cases of instruments, relays and other devices must be effectively grounded through the enclosures steel structure unless otherwise indicated. Insulated wiring having a continuous rated current of not less than the circuit fuse rating must be used for grounding.

Grounding terminals of power receptacles must be solidly grounded to the panel enclosure.

2.8.6 Convenience Outlet

A 120 volt ac, 20 amp, ground fault interruption (GFI) type duplex convenience outlet must be provided inside the panel. The outlet circuit must be separate from the panel power circuit.

2.8.7 Panel Interior Light

[Where indicated,] control panel[s] must be provided with a [60 watt incandescent] [40 watt fluorescent] [15 watt LED] light. The light must be operated by a manual on-off switch mounted on the interior door of the enclosure. The light must be powered by the same circuit as the convenience outlet.

2.8.8 Ventilation System

Where indicated, control panel[s] must be provided with two single phase, 120 volt ac ventilation fans. Each fan must supply a minimum of 100 cfm of ventilation air through the enclosure. Each fan must be provided with a line voltage thermostat. Thermostat setpoints must be adjustable in a range of 70 to 140 degrees F as a minimum. Each supply and exhaust grille must contain a filter that is easily removed for cleaning or replacement.

PART 3 EXECUTION

3.1.1 Installation

Install system components and appurtenances in accordance with the manufacturer's instructions and provide necessary interconnections, services, and adjustments required for a complete and operable system. Adjust or replace devices not conforming to the required accuracies. Replace factory sealed devices, rather than adjusting. Installation, adjustment, and operation of the equipment specified must be supervised by a manufacturer's representative experienced in the installing, adjusting, and testing of the equipment.

a. Install instrumentation and communication equipment and cable grounding as necessary to preclude ground loops, noise, and surges from adversely affecting system operation.

b. Install wiring in exposed areas, including low voltage wiring, in [metallic raceways] [EMT conduit] [rigid conduit] as specified.

c. Submit detail drawings containing complete piping, wiring, schematic, flow diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Piping and Instrumentation (P&ID) drawings (prepared using industry recognized device symbols, clearly defined and describing piping designations to define the service and materials of individual pipe segments and instrument tags employing Instrument Society of America suggested identifiers). Include in the Drawings, as appropriate: product specific catalog cuts; a drawing index; a list of symbols; a series of drawings for each process control system using abbreviations, symbols, nomenclature and identifiers as shown; valve schedules; compressed instrument air station schematics and ASME air storage tank certificates for each type and make of compressed instrument air station.

3.1.1.1 Isolation, Penetrations and Clearance from Equipment

Dielectric isolation must be provided where dissimilar metals are used for connection and support. Holes in concrete, brick, steel and wood walls must be drilled or core drilled with proper equipment; conduits installed

through openings must be sealed with materials which are compatible with existing materials. Installation must provide clearance for control-system maintenance.
Process control system installation must not interfere with the clearance requirements for mechanical and electrical system maintenance.

3.1.1.2 Device Mounting

Devices must be installed in accordance with manufacturers' recommendations and as shown. Control devices to be installed in piping must be provided with required gaskets, flanges, thermal compounds, insulation, piping, fittings, and manual valves for shutoff, equalization, purging, and calibration. Any deviations must be documented and submitted to the Contractor/Buyer for approval prior to mounting. Damaged insulation must be replaced or repaired after devices are installed to match existing work. Damaged galvanized surfaces must be repaired by touching up with zinc paint.

3.1.2 Sequences of Operation

Study the operation and sequence of local equipment controls, as a part of the conditions report, and note any deviations from the described sequences of operation on the contract drawings. Perform necessary adjustments to make the equipment operate in an optimum manner and must fully document changes made.

3.2 INSTALLATION OF EQUIPMENT

Install equipment as specified, as shown and as required in the manufacturer's instructions for a complete and fully operational control system.

3.2.1 Control Panels

Control panels must be located as indicated on the drawings. Devices located in the control panels must be as shown on the drawings or as needed to provide the indicated control sequences.

3.2.2 Flow Measuring Device

Fluid flow instruments must be installed in accordance with manufacturer's recommendations, unless otherwise indicated in the specification. The minimum straight unobstructed piping for the flowmeter installation must be
10.0 pipe diameters upstream and 5.0 pipe diameters downstream. Meters for gases and vapors must be installed in vertical piping, and meters for liquids must be installed in horizontal piping, unless otherwise recommended by the manufacturer or indicated in the specifications.

3.2.2.1 Magnetic Flowmeter

Meter must be installed in vertical piping so that the flow tube remains full of the process fluid under all operating conditions. A minimum of ten pipe diameters straight run upstream of the flowmeter and five pipe diameters straight run downstream of the flowmeter must be provided. The flowmeter and piping system must be grounded to earth ground.

3.2.3 Pressure Instruments

Pressure sensors and pressure transducers must be verified by calibration. All pressure taps must incorporate appropriate snubbers. Pressure sensors and pressure switches must have valves for isolation, venting, and taps for calibration. Pressure switches and pressure transducers installed on liquid or steam lines must have drains. Pressure transducers, differential pressure sensors and differential pressure switches must have nulling valves. Pressure switches must be adjusted to the proper setpoint and must be verified by calibration. Switch contact ratings and duty must be selected for the application.

3.2.4 Electric Power Devices

3.2.4.1 Transducers

Transducers must be wired in accordance with the manufacturer's instructions, and installed in enclosures.

3.2.4.2 Current Sensing Relays and Current Transducers for Motors

When used to sense meter/fan/pump status, current sensing relays must be used for applications under 5 hp. Applications over 5 hp must use a current transducer.

3.2.5 Output Devices

Output devices (transducers, relays, contactors, or other devices) which are not an integral part of the control panel, must be mounted in an enclosure mounted adjacent to the control panel, unless otherwise shown. Where H-O-A and/or override switches on the drawings or required by the control sequence, the switches must be installed so that the process control system controls the function through the automatic position and other controls work through the hand position.

3.2.6 Enclosures

All enclosure penetrations must be from the bottom of the enclosure, and must be sealed to preclude entry of water using a silicone rubber sealant.

3.2.7 Transformers

Transformers for control voltages below 120 VAC must be fed from the nearest power panel or motor control center, using circuits provided for the purpose. Provide a disconnect switch on the primary side and a fuse on the secondary side. Transformers must be enclosed in a steel cabinet with conduit connections.

3.3 WIRE, CABLE AND CONNECTING HARDWARE

3.3.1.1 Sensor and Control Wiring Surge Protection

Digital and analog inputs must be protected against surges induced on control and sensor wiring. Protect binary and analog outputs against surges induced on control and sensor wiring installed outdoors and as shown. Fuses must not be used for surge protection. Test the inputs and outputs in both the normal and common mode using the following two waveforms: The first waveform must be 10 microseconds by 1000 microseconds with a peak voltage of 1500 volts and a peak current of 60 amperes. The second waveform must be 8 microseconds by 20 microseconds with a peak voltage of 1000 volts and a peak current of 500 amperes. Submit certified test results for surge protection.

3.4 CONTROL DRAWINGS

3.4.1 Control

Control drawings, [framed, non-fading half-size in laminated plastic] [reproducible, with corresponding CADD files] [____], must be provided for equipment furnished and for interfaces to equipment at each respective equipment location. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system manually must be prepared in typed form, [framed as specified for the instrumentation and control diagrams] [reproducible, with corresponding word processor files] [____________________________] and posted beside the diagrams. Diagrams and instructions must be submitted prior to posting. The framed instructions must be posted before acceptance testing of the system.

3.4.2 Subcontractor Design Drawings

Subcontractor Design Drawings as a single complete package: three hard copies and three copies in electronic form. As a minimum they must include wiring, logic, and layout. Submit hardcopy drawings on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule. Subcontractor Design Drawings must be approved prior to any fabrication.

3.4.2.1 Draft As-Built

Draft As-Built Drawings as a single complete package: two hard copies and two copies in electronic form. Submit hardcopy drawings on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

3.4.2.2 Final As-Built

Final As-Built Drawings as a single complete package: three hard copies and three copies in electronic form. Submit hardcopy drawings on [ISO A1 841 by 594 mm 34 by 22 inches][or][A3 420 by 297 mm 17 by 11 inches] sheets, and electronic drawings in PDF and in [AutoCAD][Microstation][Bentley BIM V8][Autodesk Revit 2013] format. In addition, submit electronic drawings in editable Excel format for all drawings that are tabular, including but not limited to the Point Schedule and Equipment Schedule.

3.4.3 Points Schedule

Provide a Points Schedule in tabular form for each system, with the indicated columns and with each row representing a hardware point, network point or configuration point in the system.

a. When a Points Schedule was included in the Contract Drawing package, use the same fields as the Contract Drawing with updated information in addition to the indicated fields.

b. When Point Schedules are included in the contract package, items requiring Subcontractor verification or input have been shown in angle brackets ("<" and ">"), such as <___> for a required entry or <value> for a value requiring confirmation. Complete all items in brackets as well as any blank cells. Do not modify values which are not in brackets without approval. Points Schedule Columns must include:

3.4.3.1 Point Name

The abbreviated name for the point using the indicated naming convention.

3.4.3.2 Description

A brief functional description of the point such as "Supply Air Temperature".

3.4.3.3 DDC Hardware Identifier

The Unique DDC Hardware Identifier shown on the DDC Hardware Schedule and used across all drawings for the DDC Hardware containing the point.

3.4.3.4 Settings

The value and units of any setpoints, configured setpoints, configuration parameters, and settings related to each point.

3.4.3.5 Range

The range of values, including units, associated with the point, including but not limited to setpoint adjustment range, a sensor measurement range, or the status of a safety.

3.4.3.6 Input or Output (I/O) Type

The type of input or output signal associated with the point. Use the following abbreviations for entries in this column:

a. AI: The value comes from a hardware (physical) Analog Input

b. AO: The value is output as a hardware (physical) Analog Output

c. BI: The value comes from a hardware (physical) Binary Input

d. BO: The value is output as a hardware (physical) Binary Output

e. PULSE: The value comes from a hardware (physical) Pulse Accumulator Input

f. NET-IN: The value is provided from the network (generally from another
device). Use this entry only when the value is received from another device as part of scheduling or as part of a sequence of operation,

not when the value is received on the network for supervisory functions such as trending, alarming, override or display at a user interface.

g. NET-OUT: The value is provided to another controller over the network.
Use this entry only when the value is transmitted to another device as part of scheduling or as part of a sequence of operation, not when the value is transmitted on the network for supervisory functions such as trending, alarming, override or display at a user interface.

3.4.3.7 Network Data Exchange Information

(Gets Data From, Sends Data To) Provide the DDC Hardware Identifier of other DDC Hardware the point is shared with.

3.4.3.8 Override Information

For each point requiring an Override, indicate if the Object for the point is Commandable.

3.4.3.9 Trend Object Information

For each point requiring a trend, indicate if the trend is Local or Remote. For remote trends provide the DDC Hardware Identifier for the device performing the trend.

3.4.3.10 Alarm Information Indicate the Alarm Generation Type.

3.5 FIELD TESTING AND ADJUSTING EQUIPMENT

Provide personnel, equipment, instrumentation, and supplies necessary to perform site testing. The Contractor/Buyer will witness the PVT, and written permission must be obtained from the Contractor/Buyer before proceeding with the testing. Original copies of data produced, including results of each test procedure, during PVT must be turned over to the Contractor/Buyer at the conclusion of each phase of testing prior to Contractor/Buyer approval of the test. The test procedures must cover actual equipment and functions specified for the project.

3.5.1 Testing, Adjusting and Commissioning

After successful completion of the factory test as specified, the Subcontractor will be authorized to proceed with the installation of the system equipment, hardware, and software. Once the installation has been completed, tested, adjusted, and commissioned each control loop and system in accordance with NIST SP 250 and must verify proper operation of each item in the sequences of operation, including hardware and software. Calibrate field equipment, including control devices, adjust control parameters and logic (virtual) points including control loop setpoints, gain constants, constraints, and verify data communications before the system is placed online. Test installed ground rods as specified in IEEE 142 and submit certification stating that the test was performed in accordance with IEEE 142. Calibrate each instrumentation device connected to the process control system control network by making a comparison between the reading at the device and the display at the workstation, using a standard at least twice as accurate as the device to be calibrated.

Check each control point within the process control system control network by making a comparison between the control command at the central station and field-controlled device. Deliver trend logs/graphs of all points showing to the Contractor/Buyer that stable control has been achieved. Points on common systems must be trended simultaneously. One log must be provided showing concurrent samples taken once a minute for a total of [4] [____] hours. One log must be provided showing concurrent samples taken once every 30 minutes, for a total of [24] [__________________________] hours. Verify operation of systems in the specified failure modes upon Process control system network failure or loss of power, and verify that systems return to process control system control automatically upon a resumption of process control system network operation or return of power. Deliver a report describing results of functional tests, diagnostics, calibrations and commissioning procedures including written certification to the Contractor/Buyer that the installed complete system has been calibrated, tested, adjusted and commissioned and is ready to begin the PVT. The report must also include a copy of the approved PVT procedure.

3.5.2 Performance Verification Test (PVT)

Submit test procedures for the PVT. The test procedure must describe all tests to be performed and other pertinent information such as specialized test equipment required and the length of the PVT. The test procedures must explain, in detail, step-by-step actions and the expected results, to demonstrate compliance with all the requirements of the drawings and this specification. The test procedure must be site specific and based on the inputs and outputs, required calculated points and the sequence of control. Refer to the actions and expected results to demonstrate that the process control system performs in accordance with the sequence of control. Include a list of the equipment to be used during the testing plus manufacturer's name, model number, equipment function, the date of the latest calibration and the results of the latest calibration.

Demonstrate that the completed Process control system complies with the contract requirements. All physical and functional requirements of the project including communication requirements must be demonstrated and shown. Demonstrate that each system operates as required in the sequence of operation. The PVT as specified must not be started until after receipt of written permission by the Contractor/Buyer, based on the written report including certification of successful completion of testing, adjusting and commissioning as specified, and upon successful completion of training as specified. Upon successful completion of the PVT, furnish test reports and other documentation.

3.5.3 Endurance Test

Use the endurance test to demonstrate the overall system reliability of the completed system. The endurance test must be conducted in phases. The endurance test must not be started until the Contractor/Buyer notifies the Subcontractor in writing that the PVT is satisfactorily completed, training as specified has been completed, outstanding deficiencies have been satisfactorily corrected, and that the Subcontractor has permission to start the endurance test. The Contractor/Buyer may terminate testing at any time when the system fails to perform as specified. Upon termination of testing by the Contractor/Buyer or by the Subcontractor, commence an assessment period as described for Phase II. Upon successful completion of the endurance test, deliver test reports and other documentation, as specified, to the Contractor/Buyer prior to acceptance of the system.

3.5.3.1 Phase I (Testing)

The test must be conducted 24 hours per day, 7 days per week, for [_____] consecutive calendar days, including holidays, and the system must operate as specified. Make no repairs during this phase of testing unless authorized by the Contractor/Buyer in writing.

3.5.3.2 Phase II (Assessment)

After the conclusion of Phase I, identify failures, determine causes of failures, repair failures, and deliver a written report to the Contractor/Buyer. The report must explain in detail the nature of each failure, corrective action taken, results of tests performed, and must recommend the point at which testing should be resumed. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Contractor/Buyer. The meeting must not be scheduled earlier than 5 business days after receipt of the report by the Contractor/Buyer. As a part of this test review meeting, demonstrate that failures have been corrected by performing appropriate portions of the performance verification test. The Contractor/Buyer reserves the right to cancel the test review meeting if no failures or deficiencies occur during the Phase I testing. If the Contractor/Buyer chooses to do so, the Subcontractor will be notified in writing. Based on the Subcontractor's report and the test review meeting, the Contractor/Buyer will determine if retesting is necessary and the restart point. The Contractor/Buyer reserves the right to require that the Phase I test be totally or partially rerun. Do not commence any required retesting until after receipt of written notification by the Contractor/Buyer. After the conclusion of any retesting which the Contractor/Buyer may require, the Phase II assessment must be repeated as if Phase I had just been completed.

3.5.3.3 Exclusions

The Subcontractor will not be held responsible for failures resulting from the following: Outage of the main power supply in excess of the capability of any backup power source, provided that the automatic initiation of all backup sources was accomplished and that automatic shutdown and restart of the process control system performed as specified. Failure of a Government furnished communications link, provided that the PLC automatically and correctly operates in the stand-alone mode as specified, and that the failure was not due to Subcontractor furnished equipment, installation, or software. Failure of existing Government owned equipment, provided that the failure was not due to Subcontractor furnished equipment, installation, or software.

3.6 OPERATION AND MAINTENANCE DATA REQUIREMENTS

Outline the step-by-step procedures required for system startup, operation and shutdown. Include in the instructions layout, wiring and control diagrams of the system as installed, the manufacturer's name, model number, service manual, parts list and a brief description of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs and troubleshooting guides.

-- End of Section --

Attachment E:
Field Documentation Forms

Preparatory Inspections

Project Number		Field Team Leader	
Installation/Site		QC Lead	
Event Name		Project Lead	
Date		Safety Representative	

Meeting Attendees *(list additional attendees on second page)*

Name and Initials	Event Role/Position	Organization

Preparatory Steps

Planning Documents/Submittals Completed with Approvals

Item	Comments

Planning Documents/Submittals Reviewed by Field Team (Ahtna and Subcontractors)

Item	Comments

Preliminary Work Completed in Accordance with Plans

Item	Comments

Preparatory Inspections

DFOW/Tasks Discussed, and Field Team to Implement Work According to Plans	
Item	Comments

Equipment/Supplies/Materials Procured, Available, in Working Order, and Conforming to Standards (list)	
Item	Comments

Action Items

Additional Meeting Attendees

Name and Initials	Event Role/Position	Organization

Approved By

Initial ____________ Signature ____ Date ____________

Ahtna

Initial/Follow-Up QC Inspections

Project Number		Field Team Leader	
Installation/Site		QC Lead	
Event Name		Project Lead	

List of Applicable Inspection Items

Item	Inspection	Spec. Document and/or Section	QC Category & Frequency[1]
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			

[1] (W) Workmanship; (S) Safety; (M/E) Materials and Equipment; (P) Plan Compliance. Depending on the item, list one or more categories (W, S, M/E, or P) and specify the frequency of follow-up inspections.

Prepared By ______________________________ Signature ________________________________ Date ______________

Ahtna

Initial/Follow-Up QC Inspections

Project Number			
Installation/Site		QC Representative	
Event Name		Date of Inspection(s)	

Item Number and Inspection	Phase	Inspect. Type[2]				Basis[3]	Variance	Deficient	Inspector
	(I/F)[1]	W	S	M/E	P	E/N/P/O	(Y/N)[4]	(Y/N)[5]	Initial/Time
Details:									
Details:									
Details:									
Details:									
Details:									
Details:									
Details:									
Details:									

Notes:

[1] **Phase:** Initial (I); Follow-up (F)

[2] **Inspection Type:** (W) Workmanship; (S) Safety; (M/E) Materials/Equipment; (P) Plan Compliance

[3] **Basis:** (E) Existing DFOW or task; (N) New DFOW or task; (P) New personnel; (O) Other (specify) _____________

[4] **Variance:** Contact FTL/PL for variance approval, document resolution. Complete field form SWE-FFRM-004, “Work Variance” as directed by FTL..

[5] **Deficiency:** Contact FTL/PL before proceeding with work, note resolution. Complete field form SWE-FFRM-102, “Corrective Action” as directed.

Prepared By ______________________________ Signature ________________________________ Date ______________

Active Groundwater Sampling

Project Number		Field Team Leader	
Installation/Site		QAPP SOP No.	
Event Name		Date	
Field Team (name/affiliation)			
Weather Condition			

Sampler Type

○ Bailer ○ Peristaltic ○ Submersible ○ Bladder ○ Other (specify) ____________

Location

Location ID ____________ DTW(ft) ________ TD (ft) ________ Condition? ____________

☐ Check if depth is recorded in the FLB/notepad or field form SWE-FFRM-501.
Depth to water (DTW); depth to bottom (TD)

Field Measurements

Pump Inlet (ft) ________ Dewatered? ○ Yes ○ No Tubing ○ New ○ Dedicated

Time	Rate (mL/min)	Vol. (liter)	Temp. (°C)	pH (S.U.)	Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbid (NTU)	DTW (feet)	Comment
Criteria	—	—	±3%	±0.1	±3%	±2% | ±0.2	±10	±10% | <10	—	

Sample Collection (check ☐ if used for MS/MSD)

Type[1]	Field Sample ID	Date	Time	#Btls	Analyses
N					
FD					

[1] Additional sample types can be added as needed: normal (N), field duplicate (FD), equipment blank (EB), field blank (FB), and trip blank (TB)

Sample Specific Comment(s):

Initial ________ Signature ______________________________ Date ____________

Passive Groundwater Sampling

Project Number		Field Team Leader	
Installation/Site		QAPP SOP No.	
Event Name		Date	
Field Team (name/affiliation)			
Weather Condition			

Sampler Type and Station Deployment

Date ____________ Size (width × length) ______________ ◯ Membrane ◯ Rigid ◯ Snap ◯ Hydrosleeve

	Hanger ID (1, 2, 3, a, b, c)	Depth (feet)	Diameter (inch)	Length (feet)	Date	Time	Comment
Single Station							
Multiple Stations							

Location

Location ID ________________ DTW(ft) ________ TD (ft) _________ Condition? ____________________

☐ Check if depth is recorded in the FLB/notepad, field form SWE-FFRM-501, or another field form.
Depth to water (DTW); depth to bottom (TD)

Field Measurements

Pump Inlet (ft) ________ Dewatered? ☐ Yes ☐ No Tubing ☐ New ☐ Dedicated

Time	Temp. (°C)	pH (S.U.)	Cond. (µS/cm)	DO (mg/L)	ORP (mV)	Turbid (NTU)	Rate (mL/min)	Vol. (liter)	DTW (feet)	Comment

Sample Collection (check ☐ if used for MS/MSD)

Type[1]	Field Sample ID	Date	Time	#Btls	Analyses
N					
FD					

[1] Additional sample types can be added as needed: normal (N), field duplicate (FD), equipment blank (EB), field blank (FB), and trip blank (TB)

Sample Specific Comment(s):

Initial ________ Signature ______________________________________ Date ____________

Ahtna

Borehole Log

Project Number		Location ID	
Installation/Site		Start Date/Hour	
Driller		End Date/Hour	
Drilling Method		Field Geologist	
Sampling Method		Borehole Diameter (inch)	
Depth to Water (ft)		Borehole Total Depth (ft)	

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6"	Soil Description Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Ahtna

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Ahtna

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description: Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments: Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Ahtna

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description: Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments: Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Ahtna

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description: Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments: Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Ahtna

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description: Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments: Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Ahtna

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

Borehole Log

Depth BGS (ft)	Interval (ft)	Recovery (ft)	Type	Blow Counts 6-6-6" (N)	Soil Description: Lithology, USGS Classification, Color, Moisture Content, Relative Density or Consistency, Soil Structure, Interpretations	Comments: Casing Depth, Drilling Rate, Drilling Fluid Loss, Tests, and Instrumentation
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						
TBD						

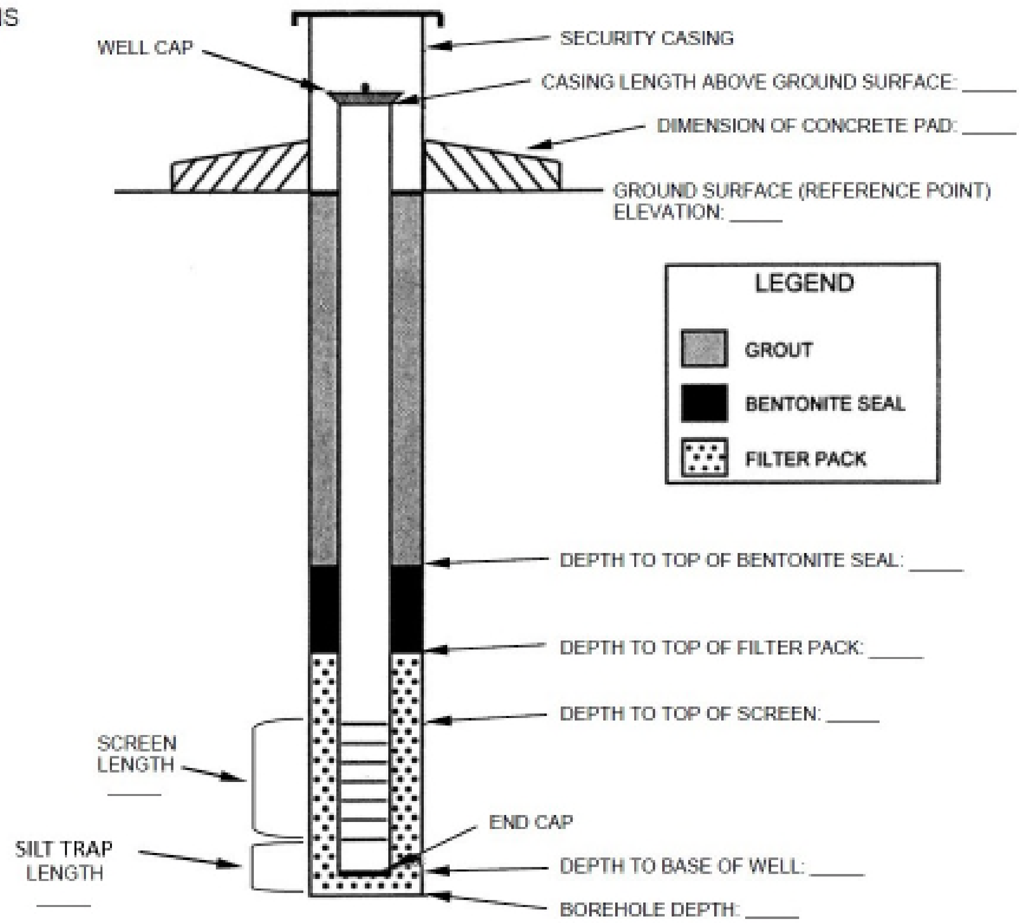
Ahtna

Well Installation Log

Project Number		Location ID	
Installation/Site		Construction Start Date	
Driller		Well Completion Date	
Field Geologist		Borehole Diameter (in)	
Casing Material		Casing Diameter (in)	
Screen Material		Slot Size (in)	
Type of Bentonite		Amt. of Bentonite (linear ft)	
Filter Pack Type		Amt. of Filter Pack (linear ft)	
Well Cap Type		End Cap Type	
Description/Dimension of Security Casing			

(ALL MEASUREMENTS IN FEET, UNLESS INDICATED OTHERWISE)

SPECIAL CONDITIONS
(describe and draw)



Comments:

Reviewed By		Date	

Ahtna

Well Development

Project Number		Well Location Name	
Installation/Site		SOP No.	
Field Team Leader		Date	
Contractor/Technician			

Description of Technique and Equipment Used (e.g., surge block, pump, bailer description, sizes, etc.)

Well Parameters

			Initial	Final
1-ft Casing Vol. (gal/ft) [1]		Total Depth (ft TOC)		
			Initial	Final
Water Column (ft)		Depth to Water (ft TOC)		
			Top	Bottom
One Well Volume (gal) [2]		Screened Interval (ft TOC)		
Pump Depth/s		Total Volume Removed		

[1] 1-ft casing volume (gal/ft) = (π × r2 × h × CF); where r = I.D. radius (in); h = 1-ft well height (i.e., 12 in); CF = conversion factor for cubic inch to gallon (0.00433 gal/cubic inch)

[2] One well volume (gal) = h × 1-ft casing volume (gal/ft) × height of water column (ft)

Well Diam. (ID)	1-ft Casing Vol. (gal/ft)**	
	Sch 40	Sch 80
2	0.17	0.15
3	0.38	0.34
4	0.66	0.59
6	1.50	1.35
8	2.60	2.37

Example: 100ft well, Water Level at 80ft, 4" diameter
100-80 = 20 20 x 0.66 = 13.2 gallons (1 well volume)
Typical Development is 10 volumes or 132 gallons for this example
*Check with PM and review work plan to determine what criteria constitutes the completion of development.

**Confirm inner diameter to calculate the volume

Field Measurements

Time	DTW	Purge Vol.	Flow Rate	Temp.	pH	Spec. Cond.	DO	ORP	Turbidity
(hh:mm)	(ft TOC)	(Gal)	(gpm)	(°C) ±3%	(S.U.) ±0.1	(µS/cm) ±3%	(mg/L) ±0.2	(mV) ±10	(NTU) <5

Observations (color, odor, NAPL, other)

Ahtna

Well Development

Time (hh:mm)	DTW (ft TOC)	Purge Vol. (Gal)	Flow Rate (gpm)	Temp. (°C) ±3%	pH (S.U.) ±0.1	Spec. Cond. (µS/cm) ±3%	DO (mg/L) ±0.2	ORP (mV) ±10	Turbidity (NTU) <5

Observations (color, odor, NAPL, other)

Ahtna

Aquifer Pumping Tests

Project Number		Extraction Well ID	
Installation/Site		Observation Well ID	
Well Diameter (inches)		Field Team Leader	
Maximum Drawdown (feet)		Field Technician	
Screen Interval (btoc) and Measuring Point Description	(Provide interval depths, screen specifications, where depth measurements are taken from if not the top of casing, and other relevant descriptions):		
Flow meter model		Flow Meter S/N or ID	

(Observations)

Field Measurements ☐ Constant-Rate Pumping Test ☐ Step-Drawdown Test

Date/Time of Measurement	Elapsed Time	Depth to Water	Totalizer Reading	Meter Pumping Rate	Comments
(mo/day hh: mm)	(minutes)	(ft bmp)	(gallon)	(gpm)	(Record "Start Step ##" for each step in the Step Drawdown Tests)
	—		—	—	Static DTW Measurement

Aquifer Pumping Tests

Date/Time of Measurement	Elapsed Time	Depth to Water	Totalizer Reading	Meter Pumping Rate	Comments
(mo/day hh: mm)	(minutes)	(ft bmp)	(gallon)	(gpm)	

Ahtna

Water Level/NAPL Measurements

Project Number		Field Team Leader	
Installation/Site		QAPP SOP No.	
Event Name		Date	
Field Team (name/affiliation)			
Weather Condition			

Type of Meter **(check those that apply)**

☐ Water Level Make/Serial# ____________ Correction (in) ________ Last Calibration ____________

☐ Interface Make/Serial# ____________ Correction (in) ________ Last Calibration ____________

Field Measurements

Location ID	Time	Ref. Point	Depth to		Total	Location-Specific Comment
		TOC[1]	NAPL (ft)	Water (ft)	Depth (ft)	

[1] If other than TOC, explain in location-specific comment

Non-aqueous phase layer (NAPL)—either light (LNAPL) or dense (DNAPL); top of casing (TOC)

(Comment)

Initial ________ Signature ____ Date ____________

Ahtna

QAPP Acknowledgment

Project Number		Project Manager	
Document Title			

Acknowledgments

Signatures indicate that participant has read the QAPP Worksheets assigned by the Project Manager and agree to implement the QAPP as written. Work variances must be approved by the Project Manager and documented in project reports.

Name/Organization	Project Role	QAPP Worksheet(s)	Signature and Date

Ahtna

Groundwater Multi-Probe Calibration

Installation/Site		Date	
Event Name		Project Number	
Field Team Leader		QAPP SOP No.	

Field Team (list name/affiliation)

Equipment Used

Manufacturer ______________ Model ______________ Serial No. ______________

Manufacturer ______________ Model ______________ Serial No. ______________

Calibration

Date	Time	Temp	pH (☐ 2 | ☐3 Pt.Cal)			SC[2]	ORP	DO	Turb.	Comment
		°C	S.U.	S.U.	S.U.	µS/cm	(mV)	Percent	NTU	
		—	4	7	10	—	—	100%	—	

[2] Recorded temperature corrected specific conductance. Most meters use internal temperature correction, but some do not.

Note: Temperature (Temp); point calibration (Pt.Cal); specific conductance (SC); oxidation-reduction potential (ORP); dissolved oxygen (DO); turbidity (Turb.)

Standards Documentation

Standard	Conc.	Unit	Manufacturer of Std.	Lot	Expires	Comment
pH 4	4.0	S.U.				
pH 7	7.0	S.U.				
pH 10	10.0	S.U.				
SC		µS/cm				
ORP		mV				
DO	100	%	n/a	n/a	n/a	Ambient air check
Turbidity		NTU				

Initial ________ Signature ________________________________ Date ______________

Ahtna

Daily QC Report (DQCR)

Project Number		Field Team Leader	
Installation/Site		Safety Representative	
Event Name		Date	
Weather Condition			

Summary of Work					
Work Performed and Significant Accomplishments					
Schedule Issues					
Deficiencies, Variances, and Resolutions					
Action Items					
Plans for Next Workday					
Hours (today)		Hours (accumulated)		Inspections Attached?	

Onsite Personal

Organization	Name	Title/Role	Arrive	Depart	Hours

Equipment

Equipment/Material Status:	Qty.	Mob	Active	Inactive	Demob

DQCR Attachments

Additional Documentation

Prepared By ____________________________ Signature ______________________________ Date ____________

Ahtna

Daily QC Report (DQCR)

Photos

Change to desired photo by:
left clicking mouse
Select "Change Picture"
Select "This Device"

Default image size = 3 X 5 inches

Photo XX:

Change to desired photo by:
left clicking mouse
Select "Change Picture"
Select "This Device"

Default image size = 3 X 5 inches

Photo XX:

Ahtna

Site Safety Tailgate Meeting

Installation/Site Name		Project Number	
Event Name		Safety Representative	
Date		Field Team Leader	
Weather Forecast:			

Participants (attach loose-leaf sheet if additional space is needed)

Printed Name and Initials	Affiliation	Role	Signature

Scope of Today's Work

Health and Safety Topics Discussed (✓ applicable topics)

☐ Weather Factors	☐ Chem. of Concern	☐ Lifting Safety	☐ Sanitation
☐ AHA Review	☐ PPE Requirements	☐ Recent near miss/injuries/lessons	☐ ____________________
☐ Site emergency SOP, rally point, etc.	☐ Slip/Trip/Fall Hazards		☐ ____________________
	☐ Site Controls	☐ BBS Hazard Triggers[1]	☐ ____________________
☐ Changed Conditions	☐ Biological Hazards	☐ BBS Trigger Controls[2]	☐ ____________________
☐ Equipment Hazards	☐ COVID 19 SOPs	☐ Traffic Control	☐ ____________________

[1] Behavior-based Safety Hazard Triggers: Distractions, rushing, short-cuts, frustration, exhaustion, complacency, anger, multi-tasking, not focusing on task

[2] Behavior-based Safety Trigger Controls: Communicating, accountability, patience, relaxation techniques, healthy lifestyle, and adequate sleep

Comments:

The individual in the Safety Representative role acknowledges that the checked (✓) topics were discussed.

Name (Print) ____________________ Signature ____________________________ Date __________

Attachment F:
Standard Operating Procedures

Fieldwork Documentation

Document Number	FSOP-001
Revision	1
Department	Ahtna Southwest Operations
Previous Document Number	Original Document
Originally Released	April 1, 2022
Effective Date	October 10, 2022

Approvals

October 10, 2022

Christopher Ohland
SWE Quality Assurance Manager

Date

October 10, 2022

Bruce Wilcer

Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS- friendly supplies and procedures.

Table of Contents

1.0 Introduction

1.1 Purpose

This SOP provides field personnel with the procedures for:

- Recording real-time, chronological logs of field activities and circumstances in field logbooks/notepads, field forms, and digital/electronic media
- Documenting fieldwork and fieldwork variances
- Ensuring documentation is reviewed, organized, and safely stored until the project closed out

Adequate documentation is necessary to describe the work performed and variances to work plans if any. Attention to detail is vital since field documentation protects our client and Ahtna with secure, legally defensible evidence and has been helpful in administrative, legal, and cost-recovery requirements. For example, field documentation may be used as evidence in legal proceedings to defend procedures and techniques employed during site investigations. Therefore, field documentation must be factual, complete, accurate, consistent, and not contain subjective language. These principles also apply when photographic or videography techniques document site activities. The goal of written, digital, and photographic/video graphics documentation is to represent field activities that accurately portray site conditions or procedures.

1.2 Scope

The scope of this SOP includes data entry and format requirements for various field documentation.

When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Project].

Written records

- Field logbooks
- Field notepads
- Field forms

Digital records

- Audio
- Photographic/video
- Data loggers

Digital data entry using field tablets is described in the EQuIS Collect User Guide.

- **Note**: *It is important to review contracts and Performance Work Statements to identify specific documentation and format requirements applicable to your project*.
- **Note**: *Contracts may contain requirements for field records. The typical* language states: "*The Contractor shall maintain field records sufficiently to recreate all field activities. The information shall be recorded in a permanently bound notebook with sequentially numbered pages. At the end of each workday, the Contractor shall complete a daily log.*"

- **Note**: *Contracts issued by the USACE may contain requirements for the project archive, both ongoing and after completion of the contract.*

1.3 Roles and Responsibilities

Field Team. A Field Team is one or more individuals working together. Each Field Team is responsible for maintaining a field log of their activities, as applicable

Field Team Lead (FTL). The FTL provides direction and oversight of the fieldwork. The FTL is responsible for reviewing and confirming the adequacy of the field documentation during fieldwork as soon as possible and before releasing the daily quality control report. The FTL keeps the Project (PL) informed of field variances or problems encountered in the field.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring that field staff has adequate experience and training to comply with this SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project. The PL documents changes as a variance to the plans and forwards the variance to the Program Manager (PgM) for approval. The PL is also responsible for confirming the adequacy of the field documentation after fieldwork. An entry confirming which information was reviewed must be added to the post-event field documentation package (Section 5.0).

Program Manager (PgM). For each SWE Program, the PgM is responsible for providing written instruction to their Field Team, which complies with the requirements of this SOP and the client-contracted specifications.

Site Supervisor.[1] The Site Supervisor is responsible for maintaining a project-specific FLB/notepad and field forms of their activities, as applicable, and providing copies to the PL for review.

Safety Representative. The Safety Representative meets the experience and training requirements of USACE EM-385-1-1 (USACE, 2014). The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of Quality Control. Method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

SWE Quality Assurance Manager and SWE Field QC Manager report to the SWE Vice-President. When mentioned in this SOP, The “SWE” prefix is shown to distinguish from the QC Lead assignment shown in the project organization chart.

[1] In this context, a Site Supervisor is a person assigned to oversee long-term operations or construction work; the roles and responsibilities are like that of the Field Team Leader.

1.4 Definitions

Field Documentation – The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

> [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

Field Notepad – An unbound, company notepad containing pre-printed heading block and space (straight-lined, grid lined, or open) for recording information. This can be an alternative to the FLB. The notepad can be paper or electronic (Word, Excel, Access, etc.) as long as a hard copy of the individual sheets is sequentially numbered and maintained in a properly labeled binder/file folder.

Field Forms – Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB. A listing of the most commonly used SWE field forms is provided in Section 2, "Relevant Documents." Each data entry field should have an entry or indicate that data for that field is not available or not required.

> [PFAS Project]: Record of field events will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard cover notebooks are not acceptable. Field logbooks are permanently assigned to a specific project.
>
> In addition, Field Form FFRM-004.00 "Daily PFAS Sampling Checklist, must be completed each day of fieldwork when activities may compromise environmental media that is sampled.

Data Loggers – Field equipment providing digital/electronic information to supplement field forms. Examples include water-level transducers for aquifer tests, flow sensors and meters in pump and treat systems, and air monitoring equipment (Section 4.1.7).

Digital/Electronic Files – Any documentation that preserves an accurate historical record of field activities but is recorded electronically through field instruments and digital devices. These records should be referenced in the FLB. Digital/electronic information includes global positioning system (GPS) coordinates, photographs, and videos.

2.0 Relevant Documents

SWE file folder m:\\Environmental\Quality Control Procedures\SWE Field Forms\ has the current, approved form templates.

3.0 Equipment List

[PFAS Project]: Products containing waterproof features (e.g., Post-it-notes, waterproof coated paper) cannot be used on per- and polyfluoroalkyl substances (PFAS) projects.

- Applicable field forms

  [PFAS Project]: Work activities will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard cover notebooks are not acceptable.

- Bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation or notepad

  [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Waterproof, indelible pens/markers in black or blue ink

  [PFAS Project]: Ball-point pens: do not use markers, felt pens, or pens with water resistant ink

- Digital camera/video, cell phone, or other devices capable of digital imagery
- Electronic device(s) for recording and storing field-related data (e.g., data loggers and GPS units)
- Batteries and charging blocks

4.0 Procedures

This section describes various mechanisms of recording documentation, including requirements and procedures. Before fieldwork, each project should define project instructions that identify the mechanism for documentation. The instruction is intended to promote procedural consistency, defined roles and responsibilities, and common language across project teams, promoting efficient reviews and cross-team utilization and training. Once established, project staff shall follow the project instruction.

4.1 Document Control and Storage

4.1.1 Project File

While in the field, the fieldwork documentation project file is managed by the FTL and consists of:

- Written records: FLB/notepads, field forms
- Digital/electronic records: photos, videos, GPS records
- Downloads from electronic devices such as data loggers

The PL is responsible for providing the location and details for storage. All field documentation is a part of the project file and should be maintained with safe document handling and archiving procedures. Hardcopy documentation and digital files are official records of fieldwork. Scans of official records are helpful for ease of access to project information and generating reports but are not official records.

The PL is responsible for all forms of field documentation, and scans of paperwork, digital records, and downloads from electronic devices are placed in the m:\\ drive project file. All original documents shall be assembled into a data package, submitted to the PL, and archived in the project file. The goal is that all documentation is organized by task/event and stored in a single location.

4.1.2 Problems in the Field and Variances from Project Plans

Variances or problems encountered during the fieldwork that cannot be resolved promptly must be communicated promptly in writing to the FTL /Site Supervisor, who will notify the PL. This may be completed by sending a variance notice by email or other means to promptly communicate the variance or problem and allow for the continuation of the fieldwork. The PL shall provide written approval of recommended solutions or provide an approved alternate solution.

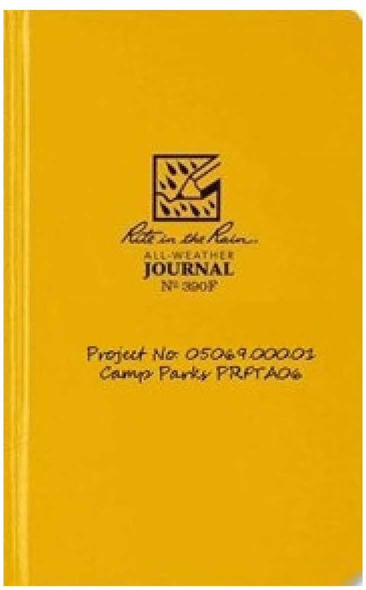
The need for a corrective action addressing variances or problems in the field will be determined by the PL in collaboration with the FTL/Site Supervisor. The PL will notify the PgM and SWE Field QC Manager of any needed corrective action for their concurrence or follow-up.

Documentation of variances to project plans, problems encountered, or corrective actions will be kept in the FLB/notepad or forms.

4.1.3 Field Logbook

Field logbooks can be spiral- or adhesive-bound and are distributed by the PgM or designee. The cover of the FLB is labeled with the project number and name of the Installation/Site(s).

The inside cover of the FLB contains the name, address, phone, and email address of the PgM and a list of projects the FLB is used to record. The information is updated if the project is assigned to another PgM.



The FLB shall be project/task-specific. The Field Team uses the FLB to record details of their responsibility (e.g., sampling, QC, safety, oversight, etc.) and provide them to the FTL/Site Supervisor for their review before submitting daily QC reports (DQCRs).

The FLB records are scanned, and the scan is saved as a PDF file on the Ahtna server in the project folder to create an electronic record for project reports. The PL shall ensure the FLBs are stored safely until project closeout. The field job box could be used for temporary storage.

4.1.4 Field Notepads

Three-ring punched, loose-leaf notepads or individual sheets can be printed on field form SWE-FFRM-001.[2] Each sheet contains a heading block, and block entries must be filled in on the first page of a new date.

Example Heading Block for Long-Term O&M or Construction

Installation/Site	Sharpe Army Depot/Sitewide	Project Number	05206.000.01.0000
Site Supervisor	Paul Marsden	Date	July 27, 2021
Subject	Telephone Record	Recorded By	Izzy Done

Example Heading Block for Environmental Studies

Project Number	05206.000.01.0000	FTL	Who Dunnit
Installation/Site	MOTCO Site 2	Recorded By	Izzy Done
Event Name	1Q 2021 GW Sampling and LF Inspection	Date	July 27, 2021

Notepads (loose-leaf paper) are used by the Field Team to record details of their responsibility (e.g., sampling, plant operations, QC, safety, oversight, etc.) and provided to the FTL/Site Supervisor for their review before submitting DQCRs.

The PL shall ensure the sheets are stored in three-ring binders or another filing system (Section 5.0), labeled with the Installation/Site name, project number, and a descriptive name of the project. If an FLB or field form is also used, a scanned copy of the FLB pages and original copies of the field forms are stored in the binder. The sheets are sequentially numbered and reviewed by the FTL/Site Supervisor. The PL reviews and approves the Site Supervisor's notepad sheets. The PL is responsible for safely storing the binder or other filing system until project closeout.

The notepad binder will be kept in the site office project file or job box. As soon as possible, the unbound records shall be scanned and saved on the Ahtna server in the m:\\ drive project folder to create an electronic record to ensure document preservation and use in project reports.

4.1.5 Field Forms

SWE-approved field form templates are available at M:\Environmental\Quality Control Procedures\SWE Field Forms\. Activity-specific SOPs reference the field forms that should be used. If preferred, individual sheets can be printed on pre-punched three-hole paper (or punched later). If the printer is capable, use a heavy paper stock for a durable form. Field forms supplement the FLB/notepad and provide a way to record detailed information using a structured format. When new forms are available, they will be posted

[2] Project-specific format designs may be used. Computer applications such as Microsoft Word or similar may also be used as long as the header information is shown, and printed copies are stored in three-ring binders.

in the template folder. The SWE Technical Writer oversees version control and will notify SWE staff when the form is posted.

Each sheet contains a heading block to enter the Installation/Site name, descriptive activity name, FTL, project number, and QAPP SOP number for the performed activity-specific fieldwork. Depending on the activity, the names of staff assigned with lead roles, weather conditions, date of recorded information, or other information may appear on the form. The heading block entries must be filled-in for each sheet to bind the field form to the project/activity.

Example Field Form Heading Block

Project Number	05108.001.02	FTL	Jared Wilson
Installation/Site	MOTCO/Site 1	SOP No.	FSOP-002
Activity Name	1Q 2021 GW Sampling and LF Inspection	Date	08/06/2021
Field Team (name/organization)	Jared Wilson/Ahtna, Izzy Done/Forever Waiting		
Weather Forecast	Sunny, 65–80°F, SW winds 5–10 mph		

Field forms are used by the Field Team to record details of their responsibility (e.g., sampling, O&M operations, QC, safety, oversight, etc.) and provided to the FTL/Site Supervisor for their review before submitting DQCRs.

The PL shall ensure the sheets are stored in three-ring binders or another filing system (Section 5.0), labeled with the Installation/Site name, project number, and a descriptive name of the project. If an FLB/notepad is also used, a scanned copy of the FLB/notepad pages and original copies of the field forms are stored in the binder. The sheets are sequentially numbered, reviewed, and approved by the PL. As soon as possible, the unbound forms shall be scanned and saved on the Ahtna server in the m:\\folder to create an electronic record to ensure document preservation and use in project reports.

The PL is responsible for safely storing the binder or other filing system until project closeout.

4.1.6 Electronic Files

Photographs and Video

All original digital field documentation (Section 1.4) shall be downloaded as soon as possible to a designated location for project use. Exclude files that are unnecessary due to unusable image quality or content. As soon as possible, the date/time, location, direction (compass point or radial degree), and purpose of the image should be documented before the information is forgotten. The use of metadata and smartphone applications to gather this information can assist. Files can be edited but maintain the original file and save the edited file with a suffix description. Alternately, use field form SWE-FFRM-002 to log photos. This form is helpful for tasks where few pictures will be taken.

The PL is responsible for providing the location and storage details. Files should be uploaded to the project folders and caption descriptions documented as soon as possible after the fieldwork ends.

Data Loggers

Examples of data loggers include equipment used in combination with:

- Water-level transducers for aquifer tests
- Flow sensors and meters in pump and treat systems
- Air monitoring equipment (e.g., particle counters)

The use of data loggers should be recorded in an FLB/notepad or field form and include the type of logger, make, model, S/N, calibration if required, and any input specifications used.

Document data acquisition activities using data loggers (data logging equipment) and related observations in the FLB.notepad. Written notes provide a permanent record of field activities that support digital data temporarily stored on various data loggers.

Specific steps and guidelines for the data acquisition activity being performed should be reviewed in the respective SOP guiding the activity.

The observations and data will be recorded in the FLB/notepad or field form. Because of the variability of features and operation of various data loggers, each field SOP and manufacturer's instructions should be carefully reviewed before beginning field activities.

The PL is responsible for providing the location and details for storage. Files should be uploaded to the project folders as soon as possible after the fieldwork ends. Files should not be edited. If needed, modifications to the captured data should be noted in the project reports. Hardcopy printouts in comma-delimited format (or similar) are recommended should the source file become corrupt.

Global Positioning Systems

GPS data acquisition activities and related observations will be digitally-recorded and later downloaded, and the file saved as described above.

Alternately, the GPS data can be recorded in field documentation to provide a permanent record of field activities supporting digital data that is temporarily stored on the GPS unit. As applicable, observations and data may be recorded in an FLB/notepad or field forms. The field forms will record the survey location identifier (e.g., well/boring location, structural feature) and corresponding coordinates and elevation.

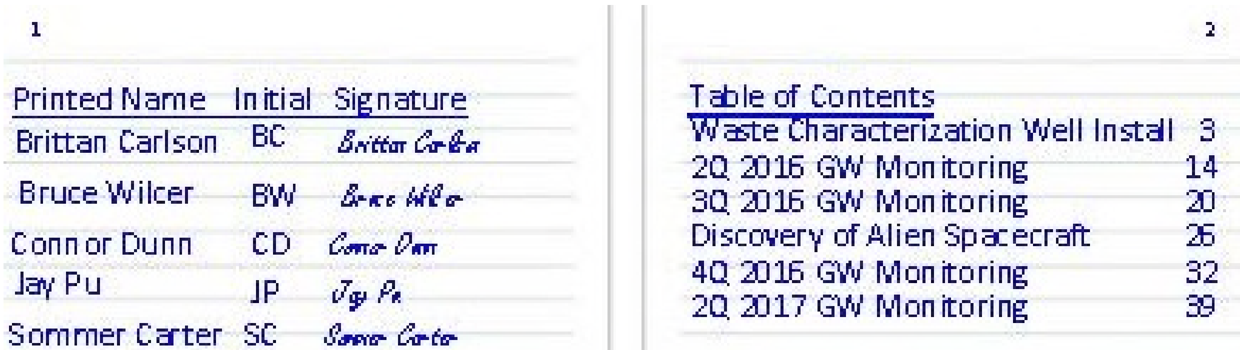
The GPS operator should also be thoroughly familiar with the manufacturer's instructions and SOP for Global Positioning System (FSOP-103) before performing GPS work in the field.

4.2 Field Logbook

The FLB is the written record of all fieldwork elements, such as Ahtna staff, subcontractors, visitors at the site, weather forecast/conditions, field equipment calibrations, construction activities, and sample collection activities. Fieldwork can be recorded on a notepad or forms described in Sections 4.3 and 4.4. When field forms are used, a brief description of the activity is added to the FLB/notepad, and details are added to the form.

4.2.1 Guidelines

Pages 1 and 2 of the FLB should be reserved to provide a signature page and table of contents. The signature page lists the employee's name, initials, and signature. The printed name and signature bind the employee to their written documentation, and the initial is helpful when limited space is available for writing a full name on subsequent pages. Each initial on page 1 must be unique. Page 2 is not required but helpful to quickly locate information in the FLB. If more space is needed, the back cover pages could be used. An entry for a significant event and the page number that initiates the documentation is typical. Open space on pages 1 and 2 does not need to be lined out, as the list will grow during work execution.



Field documentation shall adhere to the following guidelines:

- Write entries in blue or black waterproof ballpoint pen (older copier machines do not recognize other colors). Avoid felt tip pens. *Do not use a pencil*.
- List personnel making entries in the FLB and include initials and signatures on the inside cover page.
- Use a table of contents on page 2 (recommended but not required).
- Start a new page at the beginning of each day.
- Entries should be chronological – a time notation should introduce each entry.
- Language should be objective, factual, and free of personal feelings or inappropriate terminology.
- Do not erase or scratch out errors. Draw a single line through the error, then insert the corrected material. The person who corrected it shall initial and date the correction. If an explanation is needed, add that in the next available blank area in the FLB and cross-reference the error and explanation.
- The FLB shall be signed at the end of each day. Signatures shall be written on a single diagonal line drawn across the blank portion of the page following the day's last entry.
- All FLB shall be returned to the FTL/Site Supervisor for review and safe storage. The FTL/Site Supervisor shall review daily as soon as possible and before the DQCR is released.

4.2.2 Entries to Include

Initial daily entries shall include the following:

- **Date and time**: The time shall be based on military time (i.e., 2100 instead of 9 pm)
- **Field Team Leader**: Name of the Field Team Leader or Site Supervisor
- **Safety Representative**: Name of the task Safety Representative (meets EM 385-1-1 requirements)
- **QC Lead**: Name of the task QC Lead

- **Site Personnel**: Full name, title/role, and affiliation of personnel onsite, including visitors and subcontractors, with arrival and departure time noted
- **Planned Activities**: General description of various work activities for the day
- **Weather**: Weather forecast (temperature, cloud cover, wind speed, and direction). Changing weather that impact site conditions should be recorded throughout the day
- **Notes**: Taken By: Name(s) the FLB/notepad author(s)

The following are examples of ongoing daily entries. Use those and others as applicable:

- When field forms are used, record a brief description of the field activity, then record details on the field form. Do not duplicate information referenced on the field forms in the daily field documentation
- Participation in the Site Safety Tailgate Meeting, details can be added to the Site Safety and Tailgate Meeting form
- Level of personal protective equipment (PPE) and describe upgrade and downgrade of PPE levels
- Type of field instrumentation and calibrations performed, details can be added to the equipment calibration form
- Work start/stop times
- Time and location of activities
- Site physical conditions, changing weather conditions, major task decisions, or other valuable site investigation information and other essential observations
- Level of PPE and describe upgrade and downgrade of PPE levels
- All relevant field observations, major task decisions, or other valuable site investigation information
- Location of work areas if the survey has not been completed
- Survey and location of any sampling points, including swing-tie measurements
- Decontamination times and methods
- All field measurements. If field measurements of this type are being recorded on dedicated field forms, it is not necessary to record in the FLB, but the use of the form should be noted
- Type, amount, method, and location of storing and disposal for investigation-derived waste
- Changes/deviations/variances from the work plan and reason for deviations change/variance.
- Thoroughly document all FTL/Site Supervisor or PL-approved directives, guidance, or potential corrective actions from client and oversite government personnel. Directives that give personnel specific authority to make critical decisions must be documented in the FLB
- Communications with the FTL, Site Supervisor, or PL or client about decisions being made in the field
- Work deficiencies and corrective actions
- Approved work variances
- Persons contacted and topics discussed

4.2.3 Documentation of Project Variances

Thoroughly document all variances from the Performance Work Statements, Work Plans, and QAPP or changes in fieldwork procedures. Problems, delays, or any unusual occurrences such as improper equipment or breakdowns should be included, along with PL-approved resolutions. Summarize the content and conclusions of all relevant meetings, discussions, and telephone conversations that involve you.

4.2.4 References to Locations

This section applies to new locations. Established locations are referred to by the location name or code. Previously established locations are typically shown on site maps/figures.

Whenever an activity (sample collection, field measurement/monitoring, etc.) is performed at a new location (i.e., the location has not been surveyed and shown in a figure), mark the location with a survey stake or similar marker, a detailed description of the location must be recorded in the FLB/notepad or field form and accompanied by a photo, sketch, or point on an attached map as part of the daily field documentation package (sketches with accompanying photographs when appropriate, with north arrow and approximate scale). Record unusual site physical conditions or signs of contamination such as oily discharges, discolored surfaces, unusual odors, dead or distressed vegetation, including types of plants, if possible.

4.3 Notepads

When notepads are used, the requirement and procedures for the FLB (Section 4.2) also apply to the notepad documentation.

4.4 Field Forms

Field forms are used in addition to FLBs/notepads. Field forms are activity-specific and may be completed for each location/sample/well, etc., or one per field event as appropriate. Each form contains a heading block to bind the field form to the FLB/notepad. Field forms augment but do not replace the FLB/notepads. Avoid duplicating information recorded in the FLB/notepad and field form.

The forms include space (check box, table cell, and underlined space) for recording the information necessary for the project to ensure complete and proper information is recorded. Each space must be completed on a field form, and if not needed, then struck out or listing “not applicable.” Blank space can be misunderstood as missing information. Version-controlled template files of the forms are stored in the M:\Environmental\Quality Control Procedures\SWE Field Forms.

Field forms may be modified for project-specific use with the SWE Quality Assurance Manager’s approval.

All unbound data documentation is a part of the field records and should be maintained with safe document handling and archiving procedures. These records should be recorded in the same manner as notes in the FLB/field notpad using black or blue waterproof, indelible ink, and on weatherproof paper as necessary (projects testing for PFAS cannot use products with fluorinated constituents).

4.5 Field Documentation Data Package

After a short-term, specific event (e.g., well installation, sample collection, landfill inspection, and similar), copies of the FLB pages and hardcopies of loose-leaf documentation and relevant correspondence (emails and phone records) should be organized assembled into an event-based data package. The package should include a cover page listing the Installation/Site, project number, and event description.

The PL is responsible for the safe storage of the data package until project closeout. A copy of the package should be scanned and saved in the m:\\ drive project folder. The scan file could replace other scanned files described in the project instructions (Section 4.0).

If the fieldwork is a long-term task such as operating an O&M treatment system, remedial actions (e.g., excavation and disposal), or other qualifying fieldwork, the timeframe for producing the data package should be defined in the PgMs project instructions, but that period should not exceed one per year or end of the contract period.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and QC procedures for field documentation review will be performed by the FTL/Site Supervisor and checked by the PL to ensure the content and level of detail comply with this SOP. The FTL/Site Supervisor can approve variances and fieldwork problems in coordination with the PL. The FTL/Site Supervisor should try to resolve the issue so that work can continue; however, should the variance/incident/problem affect the contracted scope of work or a project decision made from the evaluation of date, the resolution must be coordinated with PgM and SWE Field QC Manager if corrective action is needed. The PgM should notify the SWE Quality Assurance Manager of all corrective actions.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0 “Procedures”) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

The PL is responsible for reviewing and signing approved documents stored in the project file (Section 4.1).

7.0 References

U.S. Department of Defense, 2013. *DoD Environmental Field Sampling Handbook, Revision 1.0*. April.

Sample Management

Document Number	SWE-FSOP-002
Revision	2
Department	Southwest Operations
Previous Document Number	Original Document
Originally Released	October 10, 2022
Effective Date	May 15, 2023

Approvals

May 15, 2023

Christopher Ohland
SWE Quality Assurance Manager

Date

May 15, 2023

Bruce Wilcer
SWE Field Quality Control Manager

Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures.
Rev 2, 05/09/2023: Inserted Section 4.5 with procedures for filling out a chain of custody form.

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques and documentation requirements to maintain sample custody and the labeling, packaging, and shipping of multimedia samples after they are collected.

Proper sample management from sample collection to laboratory receipt is essential to ensure the legal defensibility of the sample. Sample management is also needed to maintain sample integrity and successfully transport samples to the testing laboratory in an acceptable condition.

1.2 Scope

The scope of this SOP applies to field staff collecting samples. The field staff may be employed by Ahtna or by a subcontractor. Trained environmental professionals will be engaged in or directly supervise the subcontractors' collection and handling of environmental samples.

When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Project].

1.3 Responsibilities

Field Team. A Field Team is one or more individuals working together. The Field Team is responsible for the oversight of and/or collection of groundwater samples as specified in this SOP.

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of USACE EM-385-1-1 (USACE, 2014). The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. The FTL approves those actions or, if the circumstance warrants, notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Air or Ground Waybill. A shipping document that identifies the sender and addressee, transport carrier, size, and priority of a shipment transported by aircraft.

Chain of Custody. In legal contexts, is the chronological documentation or paper trail that records the sequence of custody, control, transfer, analysis, and disposition of materials, including physical or electronic evidence.

Dangerous Goods. Under the International Air Transport Association (IATA) definition, dangerous goods are articles or substances that can pose a hazard to health, safety, property, or the environment and are shown in the list of dangerous goods in the IATA regulations (IATA 1.0).

Environmental sample. According to the Department of Transportation (DOT) 49 Code of Federal Regulations (CFR) Section 172.101 Appendix A, any sample that has less than reportable quantities of any hazardous constituents.

Excepted Quantity (DOT & IATA Definition). A hazardous substance whose class is permitted on passenger aircraft but in such a small defined amount poses a low risk during transport by aircraft. Hazardous substances that meet the definition of Excepted Quantity may be exempted from documentation, packaging, marking, and labeling requirements typically required when presenting hazardous materials for passenger air transportation. Items shipped as excepted quantities are limited to volumes as specified in IATA Dangerous Goods Regulations, Table 2.6.A and DOT 49 CFR 173.4a.

Hazardous materials. DOT defines a hazardous material as any item or chemical which, when being transported or moved in commerce, is a risk to public safety or the environment and is regulated as such under its Pipeline and Hazardous Materials Safety Administration regulations (49 CFR 100-199), which includes the Hazardous Materials Regulations (49 CFR 171-180).

Sample label. An adhesive paper placed on sample containers or a tag tied to a sample container to designate a sample identification number and other identifying information.

2.0 Relevant Documents

This SOP is intended to be used in conjunction with the following SOPs, and as such, the equipment and materials needed for those activities are not included in this SOP:

Standard Operating Procedures

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-400 Series, various sampling SOPs

Field Forms

- SWE-FFRM-004, Daily PFAS Sampling Checklist
- SWE-FFRM-002, Chain of Custody

3.0 Equipment List

- Gel or bag ice (determine which is appropriate)

  [PFAS Project]: Ice in polyethylene bags

- Bubble wrap and/or foam inserts

  [PFAS Project]: Avoid packing materials that contain PFAS and materials that absorb water, including paper, cardboard, and Styrofoam; as they become soggy, they lose cushioning properties.

- Clear, strapping, or duct tape

  [PFAS Project]: Use PFAS-free tape

- Coolers
- Heavy-duty plastic bags
- [PFAS Project]: Use HDPE bags1
- [PFAS Project]: Use HDPE bags1
- Plastic zip-top bags (i.e., quart and gallon)
- Chain of Custody forms
- Air or Ground Waybills
- Sample container labels
- Custody seals for coolers

4.0 Procedures

4.1 Sample Custody

Six aspects of sample custody.

- Use appropriate sampling equipment
- Properly handle and document samples, starting from the time of collection
- Keep samples within temperature controls and safely located until offsite transport
- Properly pack and transport samples from the field site to the laboratory
- Complete the chain of custody (COC) form and include with shipment
- Verify laboratory receipt of samples
- Ensure laboratory has a custody program (subcontractor responsibility)

4.2 Proper Sampling Equipment

The supplies needed to collect samples must be made of material that will not release contaminants to the sample or hold contaminants to the sampling equipment. Equipment specifications are described in

[1] [PFAS Project]: LDPE bags may be used for bagging samples if special precautions are taken. LDPE bags should be kept separate from other sampling supplies in the staging area and should not come into direct contact with the sample media. Gloves should be changed after handling LDPE bags.

project work plans. Shipping coolers should be inspected for defects and must be decontaminated before use.

[PFAS Projects]: Surfaces in contact with the sampled media should not contain Teflon® or other PFAS-containing material.

Use new, certified sample containers suitable for the media being analyzed. Containers should be provided by the analytical lab or supplier in the appropriate quantity to accommodate required volumes for the field sample, duplicates, and any amounts required for laboratory QC processes. Certification requirements are specified in the USEPA *Specifications and Guidance for Contaminant Free Sample Containers* (EPA, 1992).

4.3 Sample Collection and Handling

Each person handling the samples must document from whom and when the item was received and to whom and when it was delivered. Documentation of handling samples is part of the custody record, which provides the mechanism for tracking samples from the time of sample collection thru laboratory analysis and disposal.

A sample is considered to be "in custody" for legal proceedings if it is:

- In a person's actual possession
- In view after being in physical possession
- Locked up so that no one can tamper with it after having been in physical custody
- In a secured area, restricted to authorized personnel only.

If any one of these is not in place at all times, sample custody is broken. The FTL should notify the PL of actions taken and document the PL decision. If corrective action is needed, the Program Manager and SWE Field Quality Control Manager should be notified.

Sampling procedures are described in the SWE-FSOP-400 series of SOPs. The Field Team is responsible for logging the sample collection in field logbooks/notepads or field forms as described in SWE-FSOP-001, "Field Documentation."

Sample custody begins at the time of sample collection, and its custody is assigned to the Field Team sample custodian. Custody transfers must be documented. Typical transfers include:

- Transfer of samples from contractors, if used, to Ahtna staff
- Transfer of samples to a transporter
- Transfer of samples to the laboratory
- Transfer of samples within the laboratory

When samples are transferred, the transfer is noted in the field logbook/notepad or field form SWE-FFRM-002, "Chain of Custody," or similar form. The name of the organization/individual and date/time of the transfer and organization/name and date/time of the recipient. For samples shipped by ground or air carrier, the unique airbill number or bill of laden should be recorded.

4.4 Sample Integrity

To reduce the possibility of invalidating the results, all collected samples must be placed in laboratory-supplied containers and labeled (Figure 1).

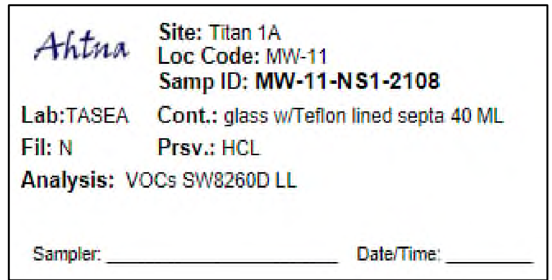


Figure 1. Example Container Label

Sample preservation before laboratory analysis is accomplished by adding the sample into pre-preserved sample containers or adding the preservative after filling the container. Preservation requirements are described in Worksheet# 19/30 of the project Quality Assurance Project Plan (QAPP).

With few exceptions (i.e., metal analyses), samples must be cooled as soon as possible after sample collection, and after that, maintained between 0°C–6°C. Samples must be kept in the custodians' possession or stored safely at all times.

Sample containers should be pre-labeled as much as practical before sample collection. Labels should be affixed to the sample container before or at sampling and must adhere firmly to the container. Labels can be further secured by placing clear packaging tape over the label, but not for volatile organic compounds (VOC) or gasoline range organics (GRO) analyses.

Sample containers that are weighed by the laboratory before use should not have any additional labels placed on the container, affecting the weight. For those containers, use the label already provided on the jar. Only one label should be placed on each sample container.

Use the specifications defined in the project work plans. Unless the QAPP specifies otherwise, sample labels should be written in indelible ink and contain, at a minimum, the following information:

- Project number/Site
- Field sample ID
- Container type and preservative
- Filtered (Y/N)
- Laboratory name
- Analysis requested (abbreviated)
- Sampler’s organization and initials
- Collection date and time (24-hour clock)

4.5 Chain of Custody

Fill out a COC form or use the COC form filled out in the field. The COC should only list the samples and bottles (specific to the analyses requested) added to the cooler. If a pre-filled COC is used and has sample IDs listed that aren’t being used, strike out the unneeded sample line(s), initial, and date. Check to ensure that the sample labels are intact, completed with the correct information, and that sample identification matches the COC record exactly.

The following information will be written on the COC form by the sample controller/shipper:

- Site name;
- Name of receiving laboratory;
- Sample IDs for all samples in a particular cooler/shipping container;
- Sample matrix or matrix code (e.g., SO for soil);
- Sample type (environmental, trip blank, equipment blank, etc.);
- Analysis requested by method number unless other arrangements are made with the receiving laboratory;
- Number of containers;
- Quality Control (QC) required (to indicate the sample is to be used for matrix spike/matrix spike duplicate analyses);
- Date of collection (mm/dd/yy or m/d/yy: 04/03/23 or 4/3/23 is April 3, 2023);
- Time of collection (military format);
- Signature of individual who prepares the COC form;
- Cooler identification (ID);
- Carrier service and airbill number.
- Signature of individual relinquishing samples along with the date and time of relinquishment.Control of the COC record will be:
- Fed Ex Shipments
  - The COC should be signed as "relinquished" by the sampler/FTL at the time it is placed inside the cooler.
  - If a triplicate form is used;
    - Original (top copy) is sealed in a waterproof zip-top bag with a custody seal (initialed and dated) and taped inside the top of the shipping container; retain the two remaining copies for Project File/submittal to the Project Manager.
  - If a single-page COC is used:
    - Scan or photograph the signed original for Project File/submittal to the Project Manager and then place the original signed copy in a waterproof zip-top bag with a custody seal (initialed and dated) and taped inside the top of the shipping container
- Laboratory Courier Shipments
  - The COC is not placed in the cooler. The COC should be signed as "relinquished" by the sampler/FTL and the courier will then take possession of the cooler and sign and write date and time in the adjacent "received" section;
  - If a triplicate form is used.
    - Original (top copy) is given to the courier; retain the two remaining copies for Project File/submittal to the Project Manager.
  - If a single-page COC is used:
    - The signed original is scanned or photographed for Project File/submittal to the Project Manager, and the original is given to the courier.

[PFAS Project]: The COC record will be placed in a re-sealable plastic Ziploc® (or equivalent) bag, the bag sealed shut to prevent water intrusion from the bagged wet ice in the cooler, and the bag taped (using PFAS-free tape) to the inside lid of the cooler.

4.6 Sample Packing

The following steps must be followed when packing sample containers for shipment:

1. Choose a cooler with structural integrity that will withstand shipment. Ensure the cooler is large enough to contain all the samples to be shipped along with the appropriate amount of ice. Use a cooler that has been pre-cooled and not one that has been in a hot vehicle or out in the sun. Secure and tape the cooler drain plug with duct tape.

   [PFAS Project]: Use ice in polyethylene bags.

2. Be sure that the caps on all sample containers are tight and do not leak but do not overtighten.
3. Wrap and package containers sufficiently to prevent cross-contamination or exposure to melt water and ensure that containers remain intact during shipment.

   [PFAS Project]: Seal each sample container in a HDPE bag to prevent melt water from getting into the sample or degrading the sample label. Taping the end of bags with duct tape will provide added protection against melt water.[1]

4. Place the containers into the cooler with caps up. No containers should be placed on their sides, as there is significantly less chance of breakage when packed vertically.
5. Use enough ice (double-bagged) to ensure that samples are received by the laboratory at the proper temperature of 0°C–6°C. For temperature-sensitive analyses, it may be necessary to cool the samples in onsite chillers. Refer to the project work plans. Although not required, the Field Team should:
   - Place a layer of ice on the bottom of the cooler.
   - Place a bag of ice vertically on one end of the cooler, followed by a set of samples. Follow this with another vertical bag of ice and repeat until the cooler is full. Make sure all samples are lined on both sides with ice.
   - Place more bags of ice flat on top of the samples.
   - Cover this with an insulating layer, such as bubble wrap.

   [PFAS Project]: Avoid packing materials that contain PFAS and materials that absorb water, including paper, cardboard, and Styrofoam; as they become soggy, they lose cushioning properties

6. Place a temperature blank in the cooler, and VOC/GRO trip blank is needed.
7. Fill excess space between sample containers and walls of the cooler with additional bubble wrap.
8. Enclose the COC form in a Ziploc bag, seal the bag, and attach it to the inside cooler cover.
9. Place a signed and dated custody seal on the outside spanning the area where the cooler lid meets the cooler's body.

   Exception. Coolers containing sample(s) that are picked up by the contracted laboratory-employed courier services do not need to show a custody seal. Custody is maintained because the samples are under the care of the courier and laboratory-employed service center staff.

[PFAS Project]: Custody seals will be pre-printed on PFAS-free paper.

10. Secure the cooler with packing tape over the custody seal.

    [PFAS Project]: PFAS-free tape will be placed over the seals to ensure that seals are not accidentally broken during shipment.

4.7 Offsite Transport

Samples taken over multiple days should be sent to the laboratory with sufficient time to allow the laboratory to meet holding time requirements. If the requested analyses have a short holding time (less than 48 hours), samples should be delivered to the laboratory for analysis as soon as possible following sample collection: preferably same day or overnight for morning delivery. Notify the laboratory Project Manager when short holding times are anticipated.

Samples can be stored onsite if: samples are left in a secure location, protected from breakage and contamination, and if the preservation specification requires, in a temperature-controlled device (e.g., ice-packed cooler or onsite refrigerator).

Sample coolers are transported to the laboratory by an Ahtna- or laboratory-employed staff or by an overnight air carrier. Coordinate delivery schedules with the laboratory Project Manager in advance. For sample transport using professional air carriers, only services that provide a tracking number can be used. The tracking number is needed to maintain sample custody. The tracking number must be listed on the chain of custody form, and a copy of the shipping receipt and tracking number should be logged in the field logbook/notepad. The package should be addressed to the “Sample Custodian.”

Transportation regulations followed by air carriers are airline-specific; some use only IATA, and others allow either IATA or DOT. Ground and vessel transportation is guided by DOT regulations. If shipping by highway or rail, no shipping paperwork is required as stated in 49 CFR 173.4a(h)1. These regulations have requirements to identify, document, label, and package samples if the shipment contains dangerous goods.

Note: United Parcel Service and Federal Express follow IATA for air shipments and DOT for ground shipments

The shipper is responsible for identifying, documenting, and packaging samples for air shipment that contains dangerous goods or whether the shipment is exempted for limited quantities. Because most multimedia samples collected for environmental projects returned in preserved containers are exempted, specific procedures are not provided in this SOP. Contact the Field QC Manager if dangerous goods shipment is suspected.

Shipments of the following may contain dangerous goods:

- If the hazardous material has a UN code
- Unknown hazardous waste from drums, sludges, or appears suspicious
- Odor, PID measurements, and physical characteristics indicate a hazard
- Explosives or radioactive materials

Keep in mind that IATA requirements and the FAA and TSA "Prohibited Items List" will not allow shippers to check dangerous goods, in any quantity, as baggage on a commercial flight.

Each sample collected will be recorded on a COC form. Each COC form(s) in a cooler or shipping container should be specific to the samples in the cooler and not samples in multiple/other coolers.

4.8 Laboratory Acknowledgment

Once the samples arrive at the laboratory, the laboratory Sample Custodian checks the shipment for:

- Levels of liquid samples to assess whether leaks have occurred
- Shipment contents match the COC form
- Check the cooler temperaure and pH if preserved.

Note: VOC/GRO analyses are checked at the sample analysis time.

The laboratory will provide notification of sample acknowledgment. The notification summarizes the work order, sample login descrepences and resolution, and discussions between the laboratory Project Manager and the Field Team. The FTL is responsible for reviewing the notification for completeness and accuracy.

4.9 Document Control

Sampling field forms should be completed in their entirety. If an entry is not applicable, indicate "n/a" (not applicable) or line out the entry.

After a task or project, all field documentation, including the field logbook, field datasheets, and electronic data, shall be scanned and placed in the appropriate folder on the server. All original documents shall be submitted to the PL and kept in the project file. See FSOP-001 (Field Documentation).

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

Verify the laboratory notice of sample acknowledgment.

6.0 Documentation Review

The FTL is responsible for daily review of the field sample management and fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

International Air Transport Association (IATA), 2019. Dangerous Goods Regulations.

Code of Federal Regulations, 49 CFR 173.4a. Excepted Quantities

USEPA Specifications and Guidance for Contaminant Free Sample Containers. EPA540/R-93/051. (December 1992)

Soil Classification

Document Number	SWE-FSOP-201
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Approvals

Christopher Ohland
SWE Quality Assurance Manager

April 1, 2022
Date

Bruce Wilcer
SWE Field Quality Control Manager

April 1, 2022
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Table of Contents

Figures

1.0 Introduction

1.1 Purpose

This Standard Operating Procedure (SOP) establishes uniform guidelines and procedures for field personnel when completing descriptions of soil samples obtained during field sampling efforts and entering the information into soil boring logs. Standardization is important to minimize variations in evaluations among geologists, which is essential for creating consistency in subsurface interpretations.

This procedure will be used during all field activities when borehole subsurface drilling, surface soil sampling, or reconnaissance geological mapping is performed. These activities should be documented as described herein and follow SWE-FSOP-001 (Field Documentation).

1.2 Scope

The scope of this SOP is to describe the data entry requirements for logging the physical properties of soil using procedures modifed from, but generally consistent with American Society for Testing Materials (ASTM) Method D2488 (Visual-Manual Procedure).

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for overseeing drilling activities according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the drilling subcontractor, logging geologic materials per SWE-FSOP-201, “Soil Classification,” and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness and accuracy of field documentation, and approval of the boring logs.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

gINT: Geotechnical and geoenvironmental software that manages borehole logs, well logs, cone penetration test (CPT), and geophysical logs.

2.0 Relevant Documents

This SOP is intended to be used in conjunction with the following documents as applicable:

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-405, Soil Sampling

3.0 Basic Equipment List

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation
- Waterproof, indelible pens/markers in black or blue ink
- Borehole log forms
- Color chart (Munsell™ or equivalent)
- Field charts of grain-size/grain percent examples
- Hand lens
- Compass
- Pocket knife
- Dilute hydrochloric acid in small dispenser/dropper bottle (if calcareous materials anticipated)
- Squirt bottle with water

4.0 Procedures

4.1 Description of Physical Properties

The following will be used as a guideline for logging lithology from surface and subsurface activities (i.e., potholing, borehole drilling, trenching, etc.). The Unified Soil Classification System (USCS) recognizes 15 soil groups and uses names and letter symbols to distinguish between these groups. The USCS groups are outlined in Figure 1 and Figure 2 with some modifications from ASTM-D2488 Unified Soil Classification System.

4.1.1 Soil Descriptions

Figure 1 and Figure 2 summarize USCS classifications and designations to use when logging samples. The coarse-grained soils are subdivided into gravels (G) and sands (S). Both the gravel and sand groups are divided into four secondary groups. Fine-grained soils are subdivided into silts (M) and clays (C). Soils are also classified according to their plasticity and grading. Plastic soils are able to change shape under the influence of applied stress and to retain the shape once the stress is removed. Soils are referred to either low (L) or high (H) plasticity. The grading of a soil sample refers to the particle size distribution of the sample. A well-graded (W) sand or gravel has a wide range of particle sizes and substantial amounts of particles sized between the coarsest and finest grains. A poorly-graded (P) sand or gravel consists predominately of one size or has a wide range of sizes with some intermediate sizes missing.

Soils that have characteristics of two groups are given boundary classifications using the names that most nearly describe the soil. The two groups are separated by a slash. The same is true when a sand could be well or poorly-graded. Again, the two groups are separated by a slash.

Soil description should be concise and stress major constituents and characteristics for fine-grained, organic, or coarse-grained soils.

4.1.2 Field Descriptions

Content of soil descriptions in the field should be based on requirements to support project objectives, utilizing criteria and nomenclature modified from ASTM D2488. Description categories may include, but are not limited to:

- **Group Name.** Name assigned to a particular lithology based on granular content, grading, and percentage of fines (specific grain sizes), described in the sections above.
- **Group Symbol**. USCS symbol corresponding to the group name, e.g., sandy silt (SM) or well-graded sand (SW).
- **Color**. The basic color of the soil, as well as staining or color change resulting from oxidation/reduction. Munsell™ soil color charts are commonly referenced for basic soil color.
- **Moisture Content**. The amount of soil moisture is described as dry, moist, or wet. Note saturated conditions and when groundwater is encountered.
- **Relative Density/Consistency**. An estimate of density of a fine-grained soil or consistency of a cohesive soil, usually based on standard penetration tests. An approximation of density/consistency can be determined by ease of penetration of the sample by thumb and/or fingers.
- **Particle (Grain) Size Distribution.** An estimate of the percentage and grain-size range of each of the soil's subordinate constituents with emphasis on clay-particle constituents. This description may also include a description of grain/particle angularity. This parameter is critical for assessing the hydrogeology of the site.
- **Soil Texture and Structure**. Description of arrangement of particles into aggregates and their structure. This description includes joints, fissures, slickened sides, bedding, veins, root holes, debris, organic content, and residual or relict structure, as well as other characteristics that may influence the movement or retention of water or contaminants.
- **Odor**. Odor is described from a warm, moist sample. The odor should only be described if it is organic or unusual. An organic odor will have a distinctive decaying vegetation smell. Unusual odors (petroleum product, chemical, and the like) should also be described.

4.1.3 Example Description

Below is an example for an interval from 7.2 feet (‘) to 9.1’ below ground surface:

Poorly-graded sand (SP), light yellowish-brown (10YR 6/4), moist to 8.5', saturated below 8.5', loose- to medium-dense, ~85% fine-grained sand with trace amount of medium-grained sand, ~15% silt, thin (~1-2mm) bedding, oxidation/reduction color change to black below 8.5'; hydrocarbon-like odor.

4.1.4 Optional Descriptions

Field soil descriptions may also include the following additional information based on project requirements or as time permits:

- **Gradation or Plasticity**. Granular soil (sands or gravels) should be described as well-graded, poorly-graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soil (silts or clays) should be described as non-plastic, low plastic, medium plastic, or highly plastic.
- **Dry Strength**. Dry strength describes the crushing characteristics of a dry soil crumb of about 1/4-inch (5 millimeters [mm]) in diameter. If a crumb of dry soil is not available, remove particles larger than No. 40 sieve size, then mold at least three balls of soil about 1/4-inch (5 mm) in diameter to the consistency of putty, adding water if necessary. Allow the balls to dry completely by oven, sun, or air drying, and then test their strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
- **Dilatancy**. Dilatancy describes the soil's reaction to shaking. After removing particles larger than No. 40 sieve size, prepare a ball of moist soil about 1/2-inch (15 mm) in diameter. Add enough water, if necessary, to make the soil soft but not sticky. Place the ball in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the ball, which then changes to a gelatinous consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the ball stiffens, and finally cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
- **Toughness**. Toughness is the consistency of the soil near the plastic limit. After removing particles larger than the No. 40 sieve size, mold a ball of soil about 1/2-inch (15 mm) in diameter to the consistency of putty. If too dry, water must be added. If too sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. The specimen is then rolled out by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. The thread is folded and rerolled repeatedly. During this manipulation, the moisture content is gradually reduced. The specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
- **Cementation**. An estimate of cementation of a coarse-grained soil.
- **Relative Permeability**. An estimate of the permeability based on visual examination of materials (e.g., high permeability for coarse sand and gravel versus low permeability for silty clay). The estimate should address the presence and condition of fractures (open, iron-stand, calcite-filled, open but clay-lined, etc.), as well as fracture density and orientation.
- **Local Geologic Name**. Any specific local name or generic name (i.e., alluvium, loess).

4.1.5 Additional Borehole Descriptions

The soil logs should also include a description of any tests run in the borehole; sample intervals, blow counts for drive samples, placement and construction details of piezometers, wells, and other monitoring equipment; geophysical logging techniques used; and notes on readings obtained by air monitoring instruments.

4.2 Document Control

At the conclusion of a task or project, all field documentation, including the, FLB/notepad, field form, and electronic data, shall be scanned and placed on the server in the appropriate folder. All original documents shall be submitted to the PL and kept in the project file.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

Occasionally, soil classification procedures described in this document may need to be updated to incorporate new description requirements.

Before field logs and soil classifications are used in analysis or to generate portions of deliverables (e.g., gINT software logs), content and accuracy of descriptions, drawings, and other field-generated information related to the logging effort should be reviewed by a knowledgeable, experienced senior reviewer to ensure the information is of the appropriate quality for use.

Quality Assurance (QA) and QC procedures for field documentation review will be performed by the PL and/or Field QC Lead to confirm that content and level of detail are in compliance with the QAPP. Identification of errors and corrections made during QA/QC reviews will follow documentation requirements described in Section 4.0.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

The Project Geologist is responsible for review and approval of soil descriptions, boring logs, well design, sieve analysis, etc. that will be used in client deliverables.

7.0 References

American Society for Testing Materials (ASTM) Method D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Figures

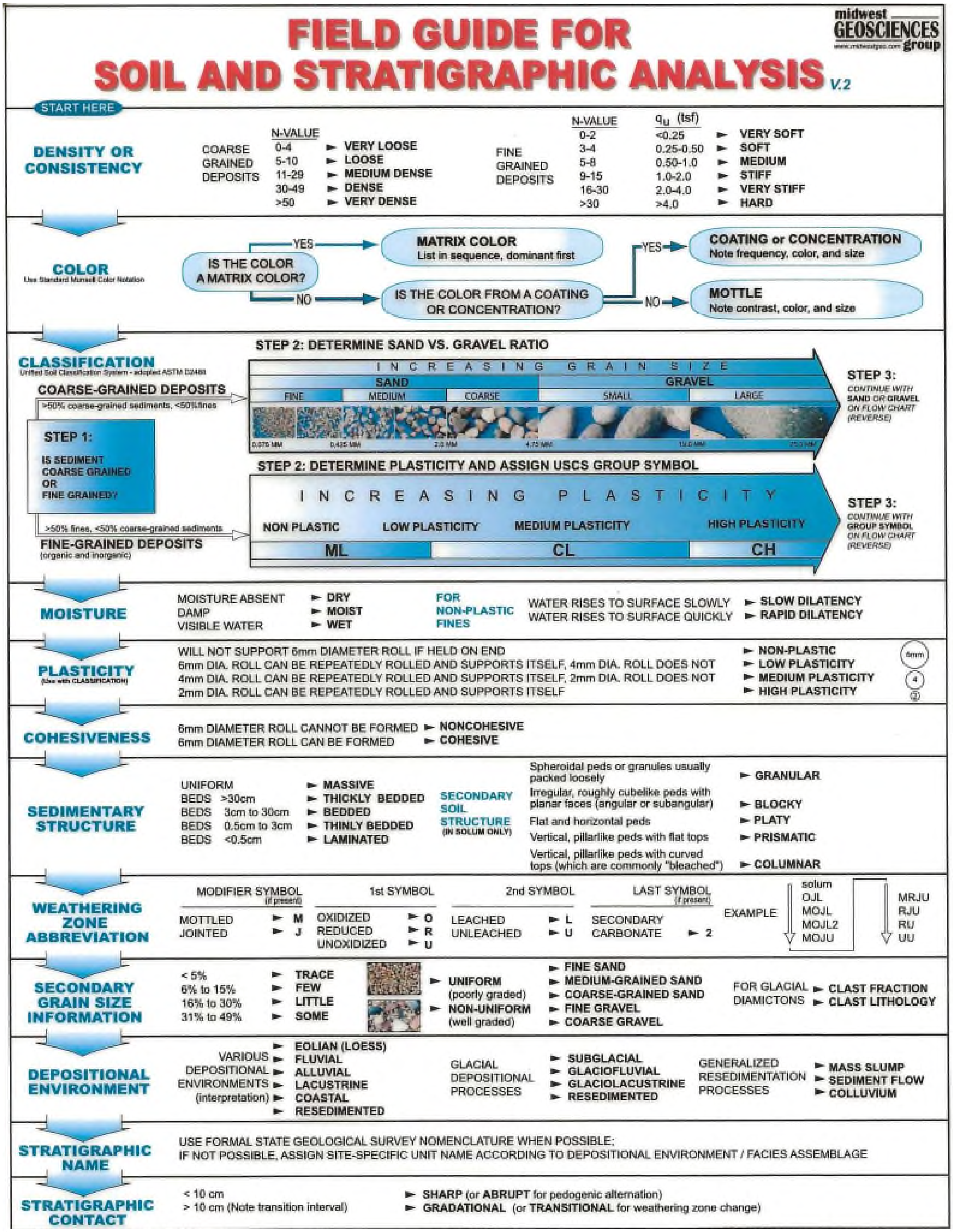

Figure 1. Field Guide for Soil and Strat 1

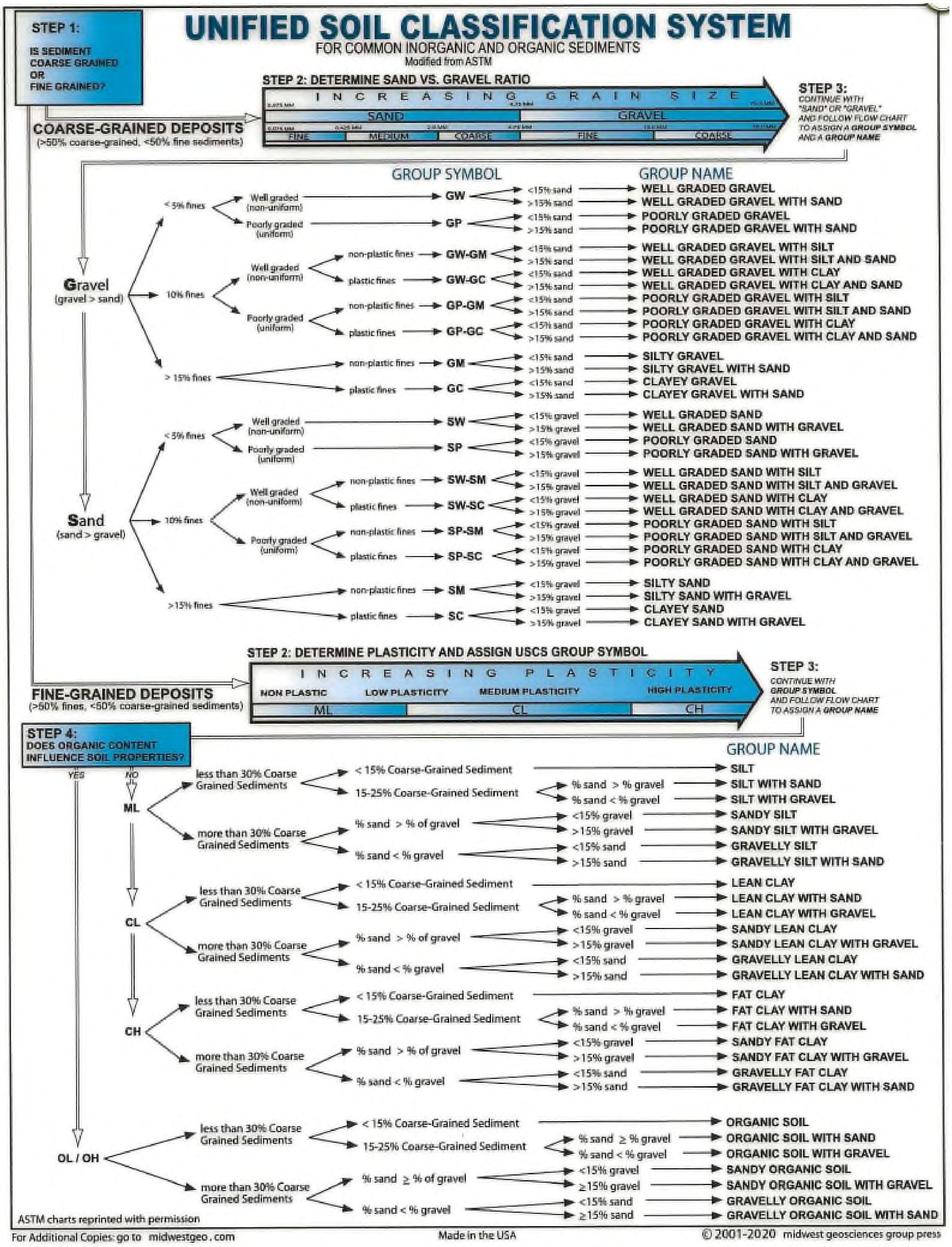

Figure 2 – Unified Soil Classification S 1

Sonic Drilling

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Approvals

Christopher Ohland
SWE Quality Assurance Manager

April 1, 2022
Date

Bruce Wilcer
SWE Field Quality Control Manager

April 1, 2022
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques and documentation of drilling operations involving sonic (also known as Rotosonic) drilling equipment.

1.2 Scope

The scope of this SOP applies to field staff conducting drilling oversight. The SOP includes guidance for the performance, management, and completion of sonic drilling activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control. Potential hazards related to drilling are addressed in project-specific Accident Prevention Plans (APP) and Site Safety and Health Plans.

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for overseeing drilling activities according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the drilling subcontractor, logging geologic materials per SWE-FSOP-201, "Soil Classification," and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness and accuracy of field documentation, and approval of the boring logs.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Boring Log - A written and/or graphical description of exploration procedures and subsurface conditions encountered during drilling, sampling, and coring.

Field Documentation – The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Forms – Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB. Each data entry field should have an entry or indicate that data for that field is not available or not required.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

Field Notepad – A unbound notepad or loose-leaf paper with consecutively numbered pages.

2.0 Relevant Documents

This SOP focuses on the oversight and documentation of sonic drilling activities and should be used in conjunction with other applicable SOPs, including the following:

Standard Operating Procedures

- SWE-FSOP-001, Fieldwork Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-201, Soil Classification
- SWE-FSOP-601, Well Installation
- SWE-FSOP-801, Equipment Decontamination
- SWE-FSOP-802, Investigation Derived Waste Management

Field Forms

- SWE-FFRM-400, Soil Boring Log

Review the project-specific work plans to become familiar with the appropriate SOPs and related field forms necessary to complete the drilling activities.

3.0 Equipment List

The list below identifies equipment expected to be used by staff while supervising sonic drilling activities.

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation
- Waterproof, indelible pens/markers in black or blue ink
- Color chart for logging soil (e.g., Munsell™ chart)
- Hand lens for examining soil
- Digital camera/video, cell phone, or other devices capable of digital imagery
- Appropriate PPE

Refer to project work plans to confirm equipment required for the specific drilling activity. This may include but is not limited to various field forms, sample containers, incremental sampling devices, and sample homogenizing equipment.

4.0 Procedures

Procedures are provided for:

- Pre-Field Tasks (Section 4.1)
- Mobilization and Setup (Section 4.2)
- Drilling Procedures (Section 4.3)
- Borehole Abandonment (Section 4.4)
- Demobilization/Site Restoration (Section 4.5)

Sonic drilling is commonly used where the Project Geologist deems issues around difficult drilling and intact core sample recovery affect the success of the work.

Sonic drilling is a method of drilling that employs two opposite-rotating elements (oscillators) in the drill head that act as counterweights working against one another. By adjusting or tuning the oscillations, high-frequency resonance is generated down the tool string to the end of the core barrel (bit), driving the bit downwards.

Cuttings are recovered as core samples or displaced outside of the borehole. Cuttings are usually transferred into a polyethylene sample bag or Lexan liner for logging and storage.

The core barrel is advanced, and the casing is advanced over the core barrel before retraction. Water may be added when working at greater depths, but it is beneficial to drill dry if the depth to groundwater needs to be determined.

A continuous core provides a detailed look at the soil at the depths drilled. This results in a better understanding of the subsurface conditions. Cuttings produced by this method are typically intact as a core sample, allowing for accurate logging.

Additional considerations in using sonic drilling techniques include the potential of volatilizing contaminants due to the heat generated by the oscillating bit.

4.1 Pre-Field Tasks

Preparation and coordination tasks for sonic drilling generally include the activities described below.

4.1.1 Clearances

Before starting any sonic boring, confirm that drilling locations have been appropriately cleared of potential overhead, surface, and subsurface hazards per the project work plans. This should include a utility locating subcontractor to identify subsurface infrastructure and anomalies. The clearance process also includes completing public utility locating service calls (e.g., Dig Alert, USA North 811, etc.) and completing any coordination and permitting procedures with the onsite Department/Directorate of Public Works personnel required by the project contract.

- Review available forms and diagrams that document the selected location of the drilling location relative to underground/overhead utility lines, surface structures, or buried objects.
- Copies of the site clearance documents should be kept onsite.

4.1.2 Health and Safety

- Hold Tailgate Safety Meetings in the manner and frequency stated in the health and safety plan.
- All personnel at the site should have appropriate training and qualifications as per the health and safety plan.
- All personnel within the exclusion zone should pay close attention to rig operations during drilling. The rotating or swinging drilling components can snag or catch loose clothing or strike personnel and cause severe injury or death.
- Hearing protection is especially critical when sonic drilling, as the rig can generate high-frequency noise and considerable noise when drilling through gravel and cobbles.
- Establishing clear communication signals with the drilling crew is mandatory since verbal signals may not be heard during the drilling process. The entire crew should be made aware to inform the driller of any unforeseen hazard—or when anyone is approaching the exclusion zone.

4.1.3 Site Conditions and Drilling Logistics

Prepare the site per the project work plans. Before mobilizing, determine the logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction. The FTL or the Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards (i.e., slip/trip/fall, overhead power lines) and determine how drilling operations may impact the environment (i.e., dust, debris, noise). As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.

- Drill site space requirements commonly include an area for the rig and swing-out clearances, access for a pipe truck, and forklift carrying pipe or debris bins.
- The FTL or the Field Geologist should inform the driller of the appropriate equipment (e.g., cookie-cutter, etc.) to penetrate the surface cover (e.g., asphalt, concrete, cement, etc.).
- Lubricating compounds used on drill pipe and drive casing threads must be approved in advance and must not contain compounds incompatible with project objectives, laboratory analyses, or water quality guidelines.
- Drive casings of various lengths should be provided by the subcontractor to facilitate emplacement of the sand pack, bentonite seal, and grout during well construction. One 3-foot, two 5-foot, and two 10-foot lengths and enough standard-length drive casing joints are recommended.
- A hydraulic casing extractor must be used to remove the drive casing from the borehole. Do not extract the casing by "hammering up" with the casing hammer. The hydraulic casing extractor should have sufficient pulling capacity and clamping mechanisms to extract the casing safely and smoothly with the appropriate lifting force.

4.1.4 Rig Decontamination and Preparation

- All drilling and sampling equipment should be decontaminated before drilling

- The drilling equipment shall be inspected for proper maintenance and appropriate decontamination before each time the rig is mobilized to a site
- All clutches, brakes, and drive heads should be properly working
- All cables and hydraulic hoses should be in good condition
- Any observed leakage of fluids from the rig should be immediately repaired and decontaminated again before it is allowed to mobilize

4.1.5 Calibration

Before mobilization, calibrate the safety-related sampling and monitoring equipment.

4.1.6 Personal Protective Equipment (PPE)

Don the appropriate PPE as specified in the project work plans and APP.

4.2 Mobilization and Setup

The standard procedure for sonic drilling is described below and the project work plans may include additional specifications.

4.2.1 Site Preparation

The logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction should be determined before mobilizing. The site should be prepared as per the project work plans.

- As per the site health and safety plan, appropriate barriers and markers should be in place before drilling
- Plastic sheeting (e.g., Visqueen™) may be required beneath the rig
- Appropriate cuttings and other IDW containment should be set onsite before the commencement of drilling
- If drilling is conducted in the saturated zone, provisions should be made to ensure adequate containment of formation water produced during drilling operations

4.2.2 Discussion of Site Conditions

Before drilling operations begin, the following must be completed:

- The FTL or Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards and determine how drilling operations may impact the environment.
- As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.
- If a shallow subsurface hazard (i.e., unidentifiable utility or trapped vapors) may exist, the driller should be informed of the potential hazard before breaking ground. Drilling should then commence slowly to allow continuous visual inspection and monitoring and, if necessary, stop for probing.

4.2.3 Mobilization

Once the site is prepared, the rig is mobilized and located over the borehole location.

- The drill rig is mobilized to the site and located over the borehole location
- The drill rig is leveled with a set of hydraulic pads attached to the front and rear of the drill rig
- The driller should always raise the mast slowly and carefully to prevent tipping or damaging the rig and avoid obstructions or hazards

4.3 Drilling Procedures

Before drilling, use a hand auger, shovel, or air knife to clear the borehole to the maximum expected depth of any utilities (commonly 5 feet or greater) to check that underground utilities are not present at the borehole. The driller should be informed of any known shallow subsurface hazards (unidentifiable utility, trapped vapors, etc.). Drilling the surface hole should commence slowly to allow continuous visual inspection and, if necessary, any interruptions for probing until the anticipated maximum depth of any suspected obstructions is exceeded.

4.3.1 Borehole Drilling

During drilling operations, and as the borehole is advanced, the Field Geologist will generally:

- Observe and monitor rig operations
- Conduct all health and safety monitoring and sampling, and supervise health and safety compliance
- Prepare a lithologic log from soil samples or cuttings per SWE-FSOP-201, “Soil Classification”
- Supervise the collection of, and prepare the soil, soil vapor, and groundwater samples
- Soil sampling for volatile organic compounds may require removing (tripping out) the entire inner drill string to collect a representative sample
- Groundwater sampling may be performed by retracting the outer casing and allowing water to flow in and be sampled using a bailer or by using a hydropunch-type sampler
- For specific soil and groundwater sampling procedures, refer to the project-specific work plans and appropriate FSOP

4.3.2 Ongoing Monitoring

The Field Geologist should observe and frequently communicate with the driller regarding drilling conditions as drilling progresses. This includes relative penetration rates (indicative of fast or slow drilling) and chattering or bucking of the rig.

- The Field Geologist oversees or conducts appropriate health and safety sampling and monitoring.
- The conditions described above, including the relative drilling rate, should be recorded on the boring log.
- The Field Geologist should know the total depth of the borehole during drilling.
- Drilling should not progress faster than the Field Geologist can adequately observe conditions, compile boring logs, and supervise safety and sampling activities.
- The Field Geologist should also observe the rig operations, including the make-up and tightening of connections as sections are added to the drill string.

- During drilling, track and note changes in the drilling process (e.g., sounds, rotation speed, sudden drops, etc.) that may indicate changes in lithology, material density, etc., and collect representative soil samples as required by the project work plans.
- Any observed problems that include significant downtime and their causes are recorded in the FLB/notepad.
- Cuttings and fluids containment during drilling should be observed and supervised by the Field Geologist, as per specifications in the project work plans.

If any potentially unsafe conditions are evident during the above drilling observations, the Field Geologist (or any onsite person) may suspend drilling operations and take appropriate actions as per the health and safety plan.

In the event suspension of drilling activities occur:

- The FTL and Safety Representative must be informed of the situation
- Appropriate corrective action must be implemented before drilling may be continued
- The observed problem, suspension, and actions taken are entered on the FLB/notepad

4.3.3 Boring Log

During drilling, the Field Geologist compiles a boring log. Use field form SWE-FFRM-400. It is expected that the log can be compiled from continuous cores or fairly representative cuttings within the core barrel recovered while drilling. Observations of drilling conditions are also entered on the log. If total depth was reached prematurely due to refusal, the cause should be noted on the boring log and the FLB.

If a monitoring well is to be installed in the borehole, a Field Geologist must supervise the work following FSOP-601, “Well Installation.”

4.4 Borehole Abandonment

If the borehole is to be abandoned after completion, the anticipated quantity of grout determined in advance and tracked during placement.

Grout consists of a neat cement mixture containing three to five percent bentonite powder to water by weight. The grout is emplaced as a slurry. The type and composition of the grout mixture should be specified in the project work plans or as determined by the Project Geologist.

Tremie-grout the borehole from bottom to top through the inside of the casing as it is retracted to ensure the grout level does not fall below the bottom opening of the casing. When the grout has reached the prescribed level (e.g., ground surface or less if special site restoration is required), allow the grout to settle and cure.

Contain any water or fluids displaced by the neat cement and contain IDW. Excess neat cement shall be placed in portable metal bins or equivalent and disposed of as solid IDW after it is allowed to set.

After 24 hours, check the grout for settling, add additional grout if necessary. Grouting is complete when the neat cement hardens, and no settlement has occurred.

Restore the final surface per the work plan and applicable specifications (e.g., repair asphalt/cement, soil placement).

If a monitoring well is to be installed in the borehole, activities will be supervised by the Field Geologist following FSOP-601, “Well Installation.”

4.5 Demobilization/Site Restoration

After drilling, sampling, and well installation or borehole abandonment is completed, the casing, drill string, and tools should be laid down, the mast lowered, and the rig moved off the location. The FTL or designee should supervise the demobilization/site restoration.

All debris generated by the drilling operation should be disposed of appropriately. The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans. All abandoned borings should be topped off and completed per the project work plans. All monitoring wells should also have their surface completions finished per the project work plans. Any hazards remaining due to drilling activities should be identified, and appropriate barriers and markers should be put in place, as per the APP. All soil cuttings and fluids should be adequately contained, clearly labeled, and maintained to comply with the project work plans.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for drilling and field documentation review will be performed by the FTL or PL to check that procedures and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

If a non-registered geologist performs the oversight, a registered Project Geologist is responsible for reviewing the fieldwork documentation for the accurate and complete representation of the drilling and approval of final logs.

6.0 Documentation Review

The FTL is responsible for daily review of the activities performed at the site and fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

None cited

Mud Rotary Drilling

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April 1, 2022

Christopher Ohland
SWE Quality Assurance Manager

Date

April 1, 2022

Bruce Wilcer
SWE Field Quality Control Manager

Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques and documentation during drilling operations involving mud rotary techniques.

1.2 Scope

The scope of this SOP applies to field staff conducting drilling oversight. The SOP includes guidance for the performance, management, and completion of mud rotary drilling activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control. Potential hazards related to drilling are addressed in project-specific Accident Prevention Plans (APP) and Site Safety and Health Plans (SSHP).

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for overseeing drilling activities according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the drilling subcontractor, logging geologic materials per SWE-FSOP-201, "Soil Classification," and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness and accuracy of field documentation, and approval of the boring logs.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. The FTL approves those actions or, if the circumstance warrants, notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Boring Log - A written and/or graphical description of exploration procedures and subsurface conditions encountered during drilling, sampling, and coring.

Field Documentation – The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Forms – Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB/notepad. Each data entry field should have an entry or indicate that data for that field is not available or not required.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

Field Notepad – A unbound notepad or loose-leaf paper with consecutively numbered pages.

2.0 Relevant Documents

This SOP focuses on the oversight and documentation of mud rotary drilling activities and should be used in conjunction with other applicable SOPs, including the following:

Standard Operating Procedures

- SWE-FSOP-001, Fieldwork Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-201, Soil Classification
- SWE-FSOP-602, Well Installation
- SWE-FSOP-801, Equipment Decontamination
- SWE-FSOP-802, Investigation Derived Waste Management

Field Forms

- SWE-FFRM-400, Soil Boring Log

Project-specific work plans should be reviewed to familiarize with the appropriate SOPs and related field forms necessary to complete the drilling activities.

3.0 Equipment List

The list below identifies basic equipment expected to be used by staff while supervising mud rotary drilling activities.

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation
- Waterproof, indelible pens/markers in black or blue ink
- Color chart for logging soil (e.g., Munsell™ chart)
- Hand lens for examining soil
- Digital camera/video, cell phone, or other devices capable of digital imagery
- Appropriate PPE

4.0 Procedure

Procedures are provided for:

- Pre-Field Tasks (Section 4.1)
- Mobilization and Setup (Section 4.2)
- Drilling Procedures (Section 4.3)
- Borehole Abandonment (Section 4.4)
- Demobilization/Site Restoration (Section 4.5)

Mud rotary drilling is an open hole, fluid-based recirculatory drilling method. The borehole is advanced in rock or sediments by rotating a drill bit mounted at the end of drill rods. Drilling fluid circulates in the borehole as it is pumped down through the drill-rod string, where it picks up drill cuttings and carries them to the surface. The drilling fluid also lubricates the drill bit and provides hydrostatic pressure in the borehole to keep the hole open and stable for sampling and well installations. Mud rotary drilling is an option for bedrock, dense sand, or tight gravel formations where hollow stem augers would be ineffective.

Applications: Best used in highly saturated silts and other unconsolidated sediments where soil sampling is necessary. Mud rotary is effective up to about 1,000 feet.

4.1 Pre-Field Tasks

Preparation and coordination tasks for mud rotary drilling generally include the activities described below.

4.1.1 Clearances

Before starting any mud rotary boring, confirm that drilling locations have been appropriately cleared of potential overhead, surface, and subsurface hazards per the project work plans. This should include a utility locating subcontractor to identify subsurface infrastructure and anomalies. The clearance process also includes completing public utility locating service calls (e.g., Dig Alert, USA North 811, etc.) and completing any coordination and permitting procedures with the onsite Department/Directorate of Public Works personnel required by the project contract.

- Review available forms and diagrams documenting the selected location of the drilling location relative to underground/overhead utility lines, surface structures, or buried objects.
- Copies of the site clearance documents should be kept onsite.

4.1.2 Health and Safety

- Tailgate Safety Meetings should be held in the manner and frequency stated in the health and safety plan.
- All personnel at the site should have appropriate training and qualifications as per the health and safety plan.
- All personnel within the exclusion zone should pay close attention to rig operations during drilling. The rotating or swinging drilling components can snag or catch loose clothing or strike personnel and cause severe injury or death.

- Establishing clear communication signals with the drilling crew is mandatory since verbal signals may not be heard during the drilling process. The entire crew should be made aware to inform the Field Geologist of any unforeseen hazard—or when anyone is approaching the exclusion zone.

4.1.3 Site Conditions, Drilling Logistics, and Equipment

Prepare the site per the project work plans. Before mobilizing, determine the logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction.

Before mobilization, the FTL or the Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards (i.e., slip/trip/fall, overhead power lines) and determine how drilling operations may impact the environment (i.e., dust, debris, noise). As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.

- Drill site space requirements commonly include an area for the rig and swing-out clearance for the cyclone, access for a pipe truck, and forklift carrying the pipe or debris bins.
- Appropriate cuttings and other investigation-derived waste (IDW) containment should be set onsite before drilling.
- The FTL or the Field Geologist should inform the driller of the appropriate equipment (e.g., cookie-cutter, etc.) to penetrate the surface cover (e.g., asphalt, concrete, cement, etc.).
- The lubricating compound used on drill pipe and drive casing threads must be approved in advance and must not contain any incompatible compounds with project objectives, laboratory analyses, or water quality guidelines.

4.1.4 Rig Decontamination and Preparation

- All drilling and sampling equipment should be decontaminated before drilling.
- The drilling equipment shall be inspected for proper maintenance and appropriate decontamination before each time the rig is mobilized to a site.
- All clutches, brakes, and drive heads should be properly working.
- All cables and hydraulic hoses should be in good condition.
- Any observed leakage of fluids from the rig should be immediately repaired and the rig decontaminated again before it is allowed to mobilize.

4.1.5 Calibration

Before mobilization, calibrate safety sampling and monitoring equipment per the project work plans.

4.1.6 Personal Protective Equipment (PPE)

Don the appropriate PPE specified in the project work plans and APP.

4.2 Mobilization and Setup

The standard procedure for mud rotary drilling is described below. Conduct drilling following this SOP and the project work plans.

4.2.1 Site Preparation

Prepare the site per the project work plans. Before mobilizing, determine the logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction.

- As per the site health and safety plan, appropriate barriers and markers should be in place before drilling.
- Plastic sheeting (e.g., Visqueen™) may be required beneath the rig.
- Appropriate cuttings and other IDW containment should be set onsite before drilling.

4.2.2 Discussion of Site Conditions

Before drilling operations begin, the following must be completed:

- The FTL or Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards and determine how drilling operations may impact the environment.
- Potential hazards should be evaluated and corrected, or the borehole location changed or shifted.
- The FTL or PL should inform the driller of the appropriate equipment (e.g., cookie-cutter, etc.) to penetrate the surface cover (e.g., asphalt, concrete, cement, etc.).
- If a shallow subsurface hazard (i.e., unidentifiable utility or trapped vapors) may exist, the driller should be informed of the potential hazard before breaking ground. Drilling should then commence slowly to allow continuous visual inspection and monitoring, if necessary, stop for probing.

4.2.3 Mobilization

Once the site is prepared, the rig is mobilized and located over the borehole.

- The drill rig is mobilized to the site and located over the borehole.
- The drill rig is leveled with a set of hydraulic pads attached to the front and rear of the drill rig.
- The driller should always raise the mast slowly and carefully to prevent tipping or to damage the rig and avoid obstructions or hazards.
- As per the site health and safety plan, appropriate barriers and markers should be placed before drilling.

4.3 Drilling Procedures

Hand auger, shovel, or air knife the borehole location to the maximum expected depth of any utilities (commonly 5 feet or greater) before drilling. The driller should be informed of any known shallow subsurface hazards (unidentifiable utility, trapped vapors, etc.). Drilling the surface hole should commence slowly to allow continuous visual inspection and, if necessary, any interruptions for probing until the anticipated maximum depth of any suspected obstructions is exceeded.

Before beginning drilling, the drilling fluid or mud should be “made up” in the mud pits. The drilling mud properties (as specified in the project work plans) should then be verified to the satisfaction of the Field Geologist before allowing drilling to proceed. These observations should also be documented by the site Field Geologist on the Field Activity Daily Log.

4.3.1 Borehole Drilling

During drilling operations, and as the borehole is advanced, the Field Geologist will generally:

- Observe and monitor rig operations
- Conduct health and safety monitoring and sampling, as applicable, and supervise health and safety compliance

- Prepare a lithologic log from cuttings, core, or soil samples
- Document drilling progress and other appropriate observations
- Supervise the collection and preparation of any soil, soil vapor, or groundwater samples
- For specific soil and groundwater sampling procedures, refer to the project-specific work plans and appropriate FSOP.

4.3.2 Ongoing Monitoring

The field geologist should observe and frequently communicate with the driller regarding drilling conditions as drilling progresses. This includes relative penetration rates (indicative of fast or slow drilling), chattering or bucking of the rig, lost circulation zones, hard or sticky drilling, drilling refusal, etc.

- The Field Geologist oversees or conducts appropriate health and safety sampling and monitoring.
- The conditions described above, including the relative drilling rate, should be recorded on the boring log.
- The Field Geologist should know the total depth of the borehole during drilling.
- Drilling should not be allowed to progress faster than the Field Geologist can adequately observe conditions, compile boring logs, and supervise safety and sampling activities.
- The Field Geologist should also observe the rig operations, including the make-up and tightening of connections and any observed leaks.
- During drilling, track and note changes in the drilling process (e.g., sounds, rotation speed, sudden drops, etc.) that may indicate changes in lithology, material density, etc., and collect representative soil samples as required by the project work plans.
- Any observed problems that include significant downtime and their causes are recorded in the FLB/notepad or field form.
- Cuttings and fluids containment during drilling should be observed and supervised by the rig geologist/engineer, as per specifications in the project work plans.

If any potentially unsafe conditions are evident during the above drilling observations, the Field Geologist (or any onsite person) may suspend drilling operations and take appropriate actions per the health and safety plan.

In the event suspension of drilling activities occur:

- The FTL and Safety Representative must be informed of the situation.
- Appropriate actions must be implemented before drilling may be continued.
- The problem, suspension, and actions taken are entered on the FLB/notepad or field form.

4.3.3 Boring Log

The Field Geologist compiles a boring log during drilling, preferably from recovered, undisturbed soil samples. Use field form SWE-FFRM-400. Logs should only be compiled from cuttings if there is no other option. Soil classification descriptions included in the boring log show follow procedures in the soil classification FSOP in Section 2.0.

Subsurface soil samples may be collected with a split spoon sampler, Shelby tube, wireline sampler, or other compatible devices during drilling. This usually requires tripping out (removing) the inner rotary drill string. The Field Geologist supervises sampling. Soil samples can be readily obtained at discrete intervals with these methods.

Observations of drilling conditions are also entered on the log. If total depth was reached prematurely due to refusal, the cause of refusal should be noted on the boring log and the FLB.

4.3.4 Geophysical Testing

Geophysical testing may be conducted at any depth by interrupting the advancement of the drill bit, cleaning the borehole of cuttings, stopping mud circulation, and removing the drill-rod column from the borehole.

Borehole geophysical tests may be run at various depths before completing the well. The Field Geologist should note the type(s) of tests run, logging conditions, distribution of log copies and originals, and any observed problems in the FLB/notepad or field form.

4.4 Borehole Abandonment

If the borehole is to be abandoned after completion, expected quantities of grout to be used should be calculated in advance and tracked during placement.

Grout consists of a neat cement mixture containing three to five percent bentonite powder to water by weight. The grout is emplaced as a slurry. The type and composition of the grout mixture should be specified in the project work plans.

Tremie-grout the borehole from bottom to top and through the inside of the casing as it is retracted. Ensure that the grout level does not fall below the bottom opening of the casing. When the grout has reached the prescribed level (e.g., ground surface or less if special site restoration is required), allow the grout to settle and cure.

Contain any water or fluids displaced by the neat cement and as IDW. Excess neat cement shall be placed in portable metal bins or equivalent and disposed of as solid IDW after it is allowed to set.

After 24 hours, check the grout for settling, add additional grout if necessary. Grouting is complete when the neat cement has hardened and no settlement has occurred.

Restore the final surface per the work plan and applicable specifications (e.g., repair asphalt/cement, soil placement).

If a monitoring well is installed in the borehole, the Field Geologist supervises activities following FSOP-601, “Well Installation.”

4.5 Demobilization/Site Restoration

After drilling, sampling, well installation, or borehole abandonment is completed, the drill rod, bit, and tools should be laid down, the mast lowered, and the rig moved off the location. The Field Geologist or appropriate designee supervises demobilization/site restoration activities.

All debris generated by the drilling operation should be disposed of appropriately. The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans. All abandoned borings should be topped off and completed per the project work plans. All monitoring wells should also have their surface completions finished per the project work plans. Any hazards remaining due to drilling activities should be identified, and appropriate barriers and markers should be put in place, as per the APP. All soil cuttings and fluids should be adequately contained, clearly labeled, and maintained to comply with the project work plans.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for drilling and field documentation review will be performed by the FTL or PL to check that procedures and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

If a non-registered geologist performs the oversight, a registered Project Geologist is responsible for reviewing the fieldwork documentation for the accurate and complete representation of the drilling and approval of final logs.

6.0 Documentation Review

The FTL is responsible for daily review of the activities performed at the site and fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

None cited

Air Rotary Drilling

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Approvals

Christopher Ohland
SWE Quality Assurance Manager

April 1, 2022
Date

Bruce Wilcer
SWE Field Quality Control Manager

April 1, 2022
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques to use during the supervision of drilling operations involving air rotary techniques and equipment.

1.2 Scope

The scope of this SOP applies to field staff conducting drilling oversight. The scope of this SOP includes guidance for activities related to the performance, management, and completion of air rotary drilling activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control. Potential hazards related to drilling are addressed in project-specific Accident Prevention Plans (APP) and Site Safety and Health Plans (SSHP).

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for overseeing drilling activities according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the drilling subcontractor, logging geologic materials per SWE-FSOP-201, "Soil Classification," and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness and accuracy of field documentation, and approval of the boring logs.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 Safety and Health Requirements. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. The FTL approves those actions or, if the circumstance warrants, notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Air Rotary Drilling—General term for methods of drilling that employ a rotating drill string (pipe and bit) to advance the borehole, using air as a circulating medium. Air is forced through the center of the drill pipe and exits the bit at the bottom of the borehole and then upward in the annular space between the borehole wall and drill pipe. The upward return stream removes cuttings from the bottom of the borehole.

Air Rotary Casing Hammer—A variation of the air rotary method. The air rotary drill string is contained inside a slightly larger diameter heavy-walled drive casing. The drive casing is advanced simultaneously with the air rotary bit using a rig-mounted hydraulic or air hammer but does not rotate with the bit. The casing maintains borehole stability, temporarily isolates aquifer/contaminated zones, and reduces lost circulation of the subsurface air stream.

Boring Log —A written and/or graphical description of exploration procedures and subsurface conditions encountered during drilling, sampling, and coring.

Field Documentation—The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Forms—Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB. Each data entry field should have an entry or indicate that data for that field is not available or not required.

Field Logbook (FLB)—A portable, bound, weatherproof notebook with consecutively numbered pages.

2.0 Relevant Documents

Relevant documents applicable to this SOP for air rotary drilling activities commonly include SOPs related to field documentation, soil sampling, and logging, groundwater and soil gas sampling, sample management, and monitoring well construction:

Standard Operating Procedures

- SWE-FSOP-001, Fieldwork Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-201, Soil Classification
- SWE-FSOP-601, Well Installation
- SWE-FSOP-801, Equipment Decontamination
- SWE-FSOP-802, Investigation Derived Waste Management

Field Forms

- SWE-FFRM-400, Soil Boring Log

Review the project-specific work plans to become familiar with the appropriate SOPs and related field forms necessary to complete the drilling activities.

3.0 Equipment List

The list below identifies basic equipment expected to be used by staff while supervising air rotary drilling activities.

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation
- Waterproof, indelible pens/markers in black or blue ink
- Color chart for logging soil (e.g., Munsell™ chart)
- Hand lens for examining soil
- Digital camera/video, cell phone, or other devices capable of digital imagery
- Appropriate PPE

Refer to project work plans to confirm equipment required for the specific drilling activity. This may include but is not limited to various field forms, sample containers, incremental sampling devices, and sample homogenizing equipment.

4.0 Procedures

Procedures are provided for:

- Pre-Field Tasks (Section 4.1)
- Mobilization and Setup (Section 4.2)
- Drilling Procedures (Section 4.3)
- Borehole Abandonment (Section 4.4)
- Demobilization/Site Restoration (Section 4.5)

Air rotary drilling without a casing is commonly limited in environmental projects to drilling in hard consolidated rock or highly consolidated sediment or soil for coring and installing wells. This method commonly has problems when drilling in unconsolidated coarse sediment or soil because the air does not provide sufficient density or viscosity to keep the borehole open while drilling, and air circulation is lost through invasion into coarse, permeable beds. Therefore, air rotary casing hammer (ARCH) drilling is covered in the remainder of this document.

ARCH drilling is applicable when installing monitoring wells as there is reasonable depth control, and the drive casing can be progressively pulled as well construction materials are placed in the borehole. Use the drive casing in unconsolidated soil and sediment to maintain borehole stability during drilling and well construction.

A variety of drilling bits may be used to penetrate various formations encountered. Cone-type bits and down-hole hammers with button bits are typically used to drill through consolidated rock, boulders, and granular soils and may incorporate an eccentric under-reaming bit assembly such as the ODEX™ or STRATEX™ systems in the drill string. Drag (fishtail) type bits are commonly used to progress through clayey and silty soils.

A disadvantage of ARCH drilling is that cuttings are typically disaggregated, making bedding and fabric determination difficult. Undisturbed soil samples can be obtained from the bottom of the hole; however, it typically requires removing the entire drill string for each sample interval.

Additional considerations in using air rotary drilling techniques include the potential of pushing vapor phase contaminants into the surrounding soil/rock matrix and flushing samples and the possibility of vapors exiting the borehole.

***Note**: Foam additives or other materials to improve air circulation in the borehole must not be used during ARCH drilling on environmental projects.*

4.1 Pre-Field Tasks

Preparation and coordination tasks for ARCH drilling generally include the activities described below.

4.1.1 Clearances

Before starting any ARCH boring, confirm that drilling locations have been appropriately cleared of potential overhead, surface, and subsurface hazards per the project work plans. This should include using a utility locating subcontractor to identify subsurface infrastructure and anomalies. The clearance process also includes completing public utility locating service calls (e.g., Dig Alert, USA North 811, etc.) and completing any coordination and permitting procedures with the onsite Department/Directorate of Public Works personnel required by the project contract.

- Review available forms and diagrams documenting the selected location of the drilling location relative to underground/overhead utility lines, surface structures, or buried objects.
- Copies of the site clearance documents should be kept onsite.
- Before drilling, the borehole location should be investigated to the maximum expected depth of any utilities (commonly 5 feet or greater) using a hand auger, shovel, or air knife.

4.1.2 Health and Safety

- Tailgate Safety Meetings should be held in the manner and frequency stated in the health and safety plan.
- All personnel at the site should have appropriate training and qualifications as per the health and safety plan.
- As per the site health and safety plan, appropriate barriers and markers should be placed before drilling.
- All personnel within the exclusion zone should pay close attention to rig operations during drilling. The rotating mechanisms can snag or catch loose clothing and cause severe injury or death.
- Hearing protection is critical when ARCH drilling, especially as the rig drive hammer strikes the drive casing as it is advanced.
- Establishing clear communication signals with the drilling crew is mandatory since verbal signals may not be heard during the drilling process. The entire crew should be made aware to inform the Field Geologist of any unforeseen hazard—or when anyone is approaching the exclusion zone.
- Close attention must be paid at all times to compressor air lines and hoses conveying cuttings to the cyclone during drilling. Obstructed lines can rupture under pressure, releasing hose sections and cuttings and debris at high velocities.

4.1.3 Site Conditions, Drilling Logistics, and Equipment

Prepare the site per the project work plans. Before mobilizing, determine the logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction.

Before mobilization, the FTL or the Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards (i.e., slip/trip/fall, overhead power lines) and determine how drilling operations may impact the environment (i.e., dust, debris, noise). As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.

- Drill site space requirements commonly include an area for the rig and swing-out clearance for the cyclone, access for a pipe truck, and forklift carrying the pipe or debris bins.
- Appropriate cuttings and other investigation-derived waste (IDW) containment should be set onsite before drilling.
- The FTL or the Field Geologist should inform the driller of the appropriate equipment (e.g., cookie-cutter, etc.) to penetrate the surface cover (e.g., asphalt, concrete, cement, etc.).
- Rigs used for ARCH drilling must have an integrated hammer handling system built into the mast assembly. A rig that requires personnel to climb onto the mast to attach or detach the hammer is unacceptable.
- The casing hammer/drill string assembly should have a sealing system sufficient to control air pressure and ensure that all cuttings, fluids, and air are discharged through the hammer exit spout.
- The hammer spout will have an attachable and removable discharge hose of sufficient size and length to reach the cyclone when the hammer is raised to the top of the mast. The hose shall be adequately anchored and attached to a cyclone that effectively decelerates cuttings from the air stream.
- An air compressor or combination of compressors should be adequate to meet minimum discharge requirements at specified pressures. Incorporated in-line filters into the air conveyance lines from the compressor(s) to remove impurities (e.g., compressor lubricating oil). Inspect the filters and change them regularly.
- The lubricating compound used on drill pipe and drive casing threads must be approved in advance and must not contain compounds incompatible with project objectives, laboratory analyses, or water quality guidelines.
- The subcontractor should provide drive casings of various lengths to facilitate emplacement of the sand pack, bentonite seal, and grout during well construction. One 3-foot, two 5-foot, and two 10-foot lengths and a sufficient number of standard length drive casing joints are recommended.
- Use a hydraulic casing extractor to remove the drive casing from the borehole. Do not extract the casing by “hammering-up” with the casing hammer. The hydraulic casing extractor should have sufficient pulling capacity and clamping mechanisms to extract the casing safely and smoothly with the appropriate lifting force.

4.1.4 Rig Decontamination and Preparation

All drilling and sampling equipment should be decontaminated before drilling as per SWE-FSOP-801, Equipment Decontamination, and the project work plans.

The driller and Field Geologist should inspect the drilling equipment for proper maintenance and appropriate decontamination before each time the rig is mobilized to a location.

- All clutches, brakes, and drive heads should be properly working.
- All cables and hoses should be in good condition.
- All drill pipes, drive casing, and bits should also be in good condition (e.g., no damaged threads on the drive casing or drill pipe or damaged or excessively worn bits).
- Any observed leakage of fluids from the rig should be immediately repaired and the rig decontaminated again before it is allowed to mobilize.

4.1.5 Calibration

Before mobilization, calibrate safety sampling and monitoring equipment per the project work plans.

4.1.6 Personal Protective Equipment (PPE)

Don the appropriate PPE specified in the project work plans and APP.

4.2 Mobilization and Setup

The standard procedure for ARCH drilling is described below. Conduct drilling following the project work plans and this SOP.

4.2.1 Site Preparation

The logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction should be determined before mobilizing. The site should be prepared as per the project work plans.

- As per the site health and safety plan, appropriate barriers and markers should be placed before drilling.
- Plastic sheeting (e.g., Visqueen™) may be required beneath the rig.
- Appropriate cuttings and other IDW containment should be set onsite before the commencement of drilling.
- If drilling is conducted in the saturated zone, provisions should ensure adequate containment of formation water produced during drilling operations.

4.2.2 Discussion of Site Conditions

Before drilling operations begin, the following must be completed:

- The FTL or the Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards and determine how drilling operations may impact the environment.
- As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.
- If a shallow subsurface hazard (i.e., unidentifiable utility or trapped vapors) may exist, the driller should be informed of the potential hazard before breaking ground. Drilling should then commence slowly to allow continuous visual inspection and monitoring and, if necessary, stop for probing.

4.2.3 Mobilization

Once the site is prepared, the rig is mobilized and located over the borehole.

- The drill rig is mobilized to the site and located over the borehole.
- The drill rig is leveled with a set of hydraulic pads attached to the front and rear of the drill rig.
- The driller should always raise the mast slowly and carefully to prevent tipping or to damage the rig and avoid obstructions or hazards.
- The cyclone should be positioned to easily collect cuttings as they drop out of the bottom opening.
- As per the site health and safety plan, appropriate barriers and markers should be placed before drilling.

4.3 Drilling Procedures

Use a hand auger to advance the borehole from 0 to 5 ft bgs to check that underground utilities are not present at each borehole location. The driller should be informed of any known shallow subsurface hazards (unidentifiable utility, trapped vapors, etc.). Drilling the surface hole should commence slowly to allow continuous visual inspection and, if necessary, any interruptions for probing until the anticipated maximum depth of any suspected obstructions is exceeded.

4.3.1 Borehole Drilling

During drilling operations, and as the borehole is advanced, the Field Geologist will generally:

- Observe and monitor rig operations;
- Conduct all health and safety monitoring and sampling, and supervise health and safety compliance;
- Prepare a lithologic log from soil samples or cuttings; and
- Supervise the collection of, and prepare the soil, soil vapor, and groundwater samples;
- Soil sampling for volatile organic compounds may require removing (tripping out) the entire inner drill string to collect a representative sample;
- Groundwater sampling may be performed by retracting the drive casing and allowing water to flow in and be sampled using a bailer or by using a hydropunch-type sampler;
- For specific soil and groundwater sampling procedures, refer to the project-specific work plans and appropriate FSOP.

4.3.2 Ongoing Monitoring

The field geologist should observe and frequently communicate with the driller regarding drilling conditions as drilling progresses. This includes relative rates of penetration (indicative of fast or slow drilling) and chattering or bucking of the rig.

- The Field Geologist oversees or conducts appropriate health and safety sampling and monitoring.
- The conditions described above, including the relative drilling rate, should be recorded on the boring log.
- The Field Geologist should know the total depth of the borehole during drilling.
- Drilling should not be allowed to progress faster than the Field Geologist can adequately observe conditions, track depth, compile boring logs, and supervise safety and sampling activities.

- The Field Geologist should also observe the rig operations, including the make-up and tightening of connections as additional drill pipe and drive casing are added to the drill string.
- During drilling, track and note changes in the drilling process (e.g., sounds, rotation speed, sudden drops, etc.) that may indicate changes in lithology, material density, etc., and collect representative cutting and soil samples as required by the project work plans.
- No leaks should be evident in the air system on the rig, including the drill pipe extending from the top head drive through the casing hammer.
- Any observed problems that include significant downtime and their causes are recorded in the FLB/notepad or field form.
- Cuttings and fluids containment during drilling should be observed and supervised by the Field Geologist, as per specifications in the project work plans.
- To improve air circulation in the borehole, foam additives or other materials, including water, must not be used during ARCH drilling on environmental projects.

If any potentially unsafe conditions are evident from the above drilling observations and the health and safety sampling and monitoring, the Field Geologist (or anyone on the Field Team) may suspend drilling operations and take appropriate actions as per the health and safety plan.

In the event suspension of drilling activities occur:

- The FTL and Safety Representative must be informed of the situation;
- Appropriate corrective action must be implemented before drilling may be continued; and
- The observed problem, suspension, and corrective action are entered on the FLB.

4.3.3 Boring Log

The Field Geologist compiles a boring log during drilling, preferably from recovere, undisturbed soil samples. Use field form SWE-FFRM-400. Logs should only be compiled from cuttings if there is no other option. Soil classification descriptions included in the boring log show follow procedures in the soil classification FSOP in Section 2.0.

Subsurface soil samples may be collected with a split spoon sampler, Shelby tube, wireline sampler, or other compatible devices during drilling. This usually requires tripping out (removing) the inner rotary drill string. The Field Geologist supervises sampling. Soil samples can be readily obtained at discrete intervals with these methods.

Observations of drilling conditions are also entered on the log. If total depth was reached prematurely due to refusal, the cause of refusal should be noted on the boring log and the FLB.

4.4 Borehole Abandonment

If the borehole is to be abandoned after completion, expected quantities of grout to be used should be calculated in advance and tracked during placement.

Grout consists of a neat cement mixture containing three to five percent bentonite powder to water by weight. The grout is emplaced as a slurry. The type and composition of the grout mixture should be specified in the project work plans.

Tremie-grout the borehole from bottom to top and through the inside of the casing as it is retracted. Ensure that the grout level does not fall below the bottom opening of the casing. When the grout has reached the prescribed level (e.g., ground surface or less if special site restoration is required), allow the grout to settle and cure.

Contain any water or fluids displaced by the neat cement as IDW. Excess neat cement shall be placed in portable metal bins or equivalent and disposed of as solid IDW after it is allowed to set.

After 24 hours, check the grout for settling, add additional grout if necessary. Grouting is complete when the neat cement has hardened and no settlement has occurred.

Restore the final surface per the work plan and applicable specifications (e.g., repair asphalt/cement, soil placement).

If a monitoring well is installed in the borehole, the Field Geologist supervises activities following FSOP-601, “Well Installation.”

4.5 Demobilization/Site Restoration

After drilling, sampling, and well installation or borehole abandonment is completed, the drill string, bits, and tools should be laid down, the mast lowered, and the rig moved off the location. The Field Geologist or appropriate designee supervises demobilization/site restoration activities.

All debris generated by the drilling operation should be disposed of appropriately. The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans. All abandoned borings should be topped off and completed per the project work plans. All monitoring wells should also have their surface completions finished per the project work plans. Any hazards remaining due to drilling activities should be identified, and appropriate barriers and markers should be put in place, as per the APP. All soil cuttings and fluids should be properly contained, clearly labeled, and maintained in compliance with the project work plans.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for drilling and field documentation review will be performed by the FTL or PL to check that procedures and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

If a non-registered geologist performs the oversight, a registered Project Geologist is responsible for reviewing the fieldwork documentation for the accurate and complete representation of the drilling and approval of final logs.

6.0 Documentation Review

The FTL is responsible for daily review of the activities performed at the site and fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

None cited

Active Groundwater Sampling

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Revision	1
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Approvals

Christopher Ohland — October 10, 2022
Christopher Ohland — Date
SWE Quality Assurance Manager

Bruce Wilcer — October 10, 2022
Bruce Wilcer — Date
SWE Field Quality Control Manager

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques and documentation requirements to collect groundwater samples using active sampling techniques.

In general, active groundwater sampling involves purging temporary or permanent wells using equipment such as bailers, submersible pumps, and peristaltic (low-flow) pumps. Groundwater samples are then pumped or poured into clean-certified sample containers. These samples are packaged and submitted for laboratory tests. In most instances, the laboratory performs sub-part per million tests; thus, care must be taken to minimize cross-contamination of the collected sample.

1.2 Scope

The scope of this SOP applies to field staff collecting groundwater samples using active sampling techniques from temporary and permanently installed wells. The field staff may be employed by Ahtna or by a subcontractor. Trained environmental professionals will be engaged in or directly supervise the subcontractors' collection and handling of environmental samples.

> Per- and polyfluoroalkyl substances (PFAS) friendly procedures are also provided in this SOP. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Projects].

1.3 Responsibilities

Field Team. A Field Team is one or more individuals working together. The Field Team is responsible for the oversight of and/or collection of groundwater samples as specified in this SOP.

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of USACE EM-385-1-1 (USACE, 2014). The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. The FTL approves those actions or, if the circumstance warrants, notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of Quality Control. method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Bailer. A bottom-filling cylindrical tube with a check valve at the bottom. A bailer is not recommended for sampling volatile organic compounds (VOCs), gasoline range organics (GRO), or metals.

Bladder Pump. A positive-displacement pump is used to pump groundwater to the surface from most depths. A bladder pump can be small enough to sample from wells as small as 3/4-inch in diameter.

Peristaltic Pump. A negative air pressure pump is used to draw groundwater to the surface. These pumps can be used if the depth to water is less than approximately 25 feet. Due to a potential loss of the volatile fraction from negative pressure gradients, peristaltic pumps are generally not recommended for well purging and sampling when VOC analysis is required.

Submersible Pump. A positive-displacement pump is used to pump groundwater to the surface. Achievable depths are limited by the power of the pump and the length of the wiring. The well must be at least 2 inches in diameter.

2.0 Relevant Documents

This SOP focuses on the groundwater purging and sample collection tasks and applications and should be used in conjunction with other applicable SOPs, including the following:

Standard Operating Procedures

SWE-FSOP-001, Field Documentation
SWE-FSOP-002, Field Sample Management
SWE-FSOP-101, Water Quality Measurements
SWE-FSOP-102, Groundwater and NAPL Measurements
SWE-FSOP-801, Equipment Decontamination
SWE-FSOP-802, IDW Management

Field Forms

SWE-FFRM-004, Daily PFAS Sampling Checkist [PFAS Projects]
SWE-FFRM-300, Groundwater Sampling
SWE-FFRM-501, Water Level/NAPL Measurements
SWE-FFRM-801, Equipment Calibration

3.0 Equipment and Materials List

Multiple types of equipment can be used to purge and sample groundwater. The correct equipment to use should be determined by the PL based on site conditions and analyses to be performed.

Materials used during groundwater sampling must not absorb, desorb, or leach contaminants of concern from or into a potential groundwater sample. The materials used must be resistant to chemical and biological degradation.

Sampling Devices

- Bailer
- Bladder Pump and associated controller
- Peristaltic Pump
- Submersible Pump

  [PFAS Projects]: Surfaces in contact with the sampled media (e.g., bailers) should not contain Teflon® or other PFAS-containing material.

Other Equipment/Supplies

- Chain of custody forms and custody seals
- Clean cooler
- Decontamination equipment including soap (i.e., Liquinox™), de-ionized and tap water
- Electronic water level meter such as the Solinst Model 101 or equivalent
- Waterproof, indelible pens/markers in black or blue ink

  [PFAS Project]: Use ball-point pens. Do not use markers, felt pens, or pens with water resistant ink.

- Field logbook

  [PFAS Project]: Field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Field forms

  [PFAS Project]: Record of field events will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard cover notebooks are not acceptable. Field logbooks are permanently assigned to a specific project.

- Gel or bag ice (determine which is appropriate)

  [PFAS Project]: Ice in polyethylene bags

- Graduated cylinder for checking flow rates
- Health and safety equipment including safety glasses and nitrile/latex exam gloves as specified in the project Health and Safety Plan
- IDW Labels
- Meter calibration standards
- 0.45-micron field filters
- Multimeter with flow-through-cell or cup
- Oil/water interface probe, if non-aqueous phase liquid (NAPL) is expected
- Packaging materials

  [PFAS Project]: Use non-PFAS containing packaging paper

- Packaging tape

[PFAS Project]: Use PFAS-free tape

- Paper towels
- Purge water storage (drums, tanks, etc.)
- Sample bottles

[PFAS Project]: Do not use glass, LDPE, or Teflon®-lined caps.

- Sample Labels
- Sample tubing (inert material)

[PFAS Project]: Do not use Teflon®-lined tubing.

- Timing device
- Tools to open wells
- Vehicle battery (or external power supply) to power pump with pump controller

4.0 Procedures

Procedures are provided for:

- Pre-sampling tasks (Section 4.1)
- Preparing a well for collecting representative samples (Section 4.2)
- Sampling using four different devices (Section 4.3 to 4.6)
- Filling sampling containers (Section 4.7)
- Document control (Section 4.8)

4.1 Pre-Sampling Tasks

The PL or FTL should rank sampling locations based on the concentrations of target analytes. The highest concentrations should be sampled last to minimize potential cross-contamination. The PL should provide instruction for the order of sampling or whether contaminant-level ranking is necessary.

The most recent groundwater levels and water quality data should be available to the Field Team. That information is used to evaluate the reasonableness of the water level and water quality measurements of the current event. Unusual measurements should be verified.

Determine the intended pump intake placement in advance, considering the most recent water level measurement. Typically, the screen midpoint is used or a depth selected from the evaluation of multi-depth sampling. The PL shall ensure those depths are available to the Field Team.

Decontaminate all equipment that could come into contact with sampling equipment and decontaminate and calibrate all instruments before obtaining field data according to SWE-FSOP-801 (Equipment Decontamination) and SWE-FSOP-107 (Equipment Calibrations). Equipment in contact with groundwater at one location must be decontaminated before reusing at another location.

[PFAS Project]: Reusable non-dedicated equipment will be rinsed with certified PFAS-free water prior to and following the collection of each sample. If another source of water is used, collect a water sample and run laboratory tests for PFAS before using that source.

If NAPL (such as floating/heavier-than-water product) is suspected in the well, check for NAPL presence using an oil/water interface probe. If detected, record the presence and thickness of NAPL in the field notebook (SWE-FSOP-102. "Groundwater and NAPL Measurements").

Before groundwater purging and sampling, measure groundwater depths (and total depths if needed) to assess the site hydrogeologic conditions. Measure the depth to groundwater in each well to within 0.01 feet. Measurements can be performed as one activity or individually when combined with the sampling effort. Ideally, depth to water measurements should be taken within one day. In practice, measurements should be taken within a few days but not longer than one week. If fieldwork is performed outside this guideline, the PL shall instruct the FTL. Conditions that should trigger discussions are heavy rainfalls, tidal influences, excessive nearby groundwater extraction, or other unusual condition.

4.2 Representative Samples

4.2.1 Purging

If left standing, the well's groundwater can become stagnant or change in ways that make it unrepresentative of the groundwater to be collected. Groundwater purging is a procedure that draws fresh groundwater from the surrounding formation into the well immediately prior to sample collection.

When purging with a motorized pump, care should be taken to maintain the height of the groundwater table as measured by "depth to water." Excessive pumping pulls water from above and below the intended position for collecting samples.

For low-flow sampling techniques, pumping rates from 100 mL/minute to 500 mL/minute (DTSC, 2008).

Equipment-specific purging techniques are described in Sections 4.3 through 4.6.

4.2.2 Groundwater Parameters

Groundwater quality parameters are collected for two reasons.

To show that purging activites have conditioned the well water so that a representative sample can be collected at a specified well depth.
To collect water quality measurements commonly used in engineering and science evaluations.

Using low-flow sampling techniques, a well's groundwater is considered representative at the screened-interval of the well when successive measurements have met criteria.

> ***Note***. Techniques other than low-flow may use three well volumes as the criteria for a representative sample (Sections 4.3–4.6).

Using a calibrated multimeter, water quality parameters are measured. Depending upon the sampling technique, the multimeter probes will be connected to a flow-through cell or a manufacturer-supplied cup.

During low-flow sampling, measurements are recorded at the onset of purging and then every three to five minutes. When three successive readings meet stability criteria listed below, the well water is ready for sampling. The final measurement is used for project evaluations and reporting.

For bailer and submerisible sampling techniques, a single measurement is collected after three well volumes have been purged or the well drys and recovers. Using a cup provided by the manufacturer (or similar). Allow the parmaters to stabilize before loging the readings.

> ***Note****. Some project work plans specify water quality measurements after each well volume. Consult the PL or FTL for the project specifications.*

If the project requires downhole parameters to be measured, lower the probe to the well screeen midpoint; once readings stabilize, one set of parameters are recorded.

Well water stability criteria (EPA, 2017):

DO	± 10 percent or ±0.2 mg/L, depending on units of measure
Specific conductance	± 3 percent (microsiemens per cm)
ORP	± 10 millivolts
pH	± 0.1 units
Turbidity	± 10% or less than 10.0 NTU (Nephelometric turbidity unit)
Temperature	$\pm$3% °C

Turbidity stabilization can be problematic. If other parameters have stabilized but not turbidity, the FTL may determine that the purging meets the objectives of obtaining a representative sample and terminate the need for additional purging volume.

4.3 Bailer Sampling

1. Measure groundwater level, then depth to bottom if needed. Decontaminate the sounder.
2. Tie a rope of appropriate size and material to the top of a disposable or stainless-steel bailer and the other end to an unmovable object.
3. Slowly lower the bailer into the water column to avoid disturbing sediment; stop lowering when the bailer is full.
4. Raise the bailer to the surface, keeping the removed rope on a clean surface such as plastic sheeting or in your hands.
5. Contents of the bailer are dumped into a marked container such as a tank, drum, or bucket. The container has markings to track the volume of water purged from the well. Bail until at least three well volumes have been removed or the well has been dewatered.
6. Collect one set of water quality measurements from a fresh aliquot of sample after finished the well purging. Measurements are taken from a cup supplied with the multimeter.

   Note*. Some project work plans specify water quality measurements after each well volume. Consult the PL or FTL for the project specifications.*

7. Using the bailer tip or sample valve inserted at the check ball, empty contents into sample containers. If sampling for VOC/GRO, use a VOC tip to dispense the sample into the appropriate sample container (See Section 4.7 “Filling Sample Containers”).
8. If the well dewaters, collect samples after the well recharges to approximately 80 percent of its pre-purge volume. However, if its unlikely to achieve 80 percent recover, collect samples for the

VOC/GRO analysis without waiting. Volatile compounds will escape if the water column is small, use your best judgment, and log the actions taken.

9. In cases where recharge volume is insufficient to fill all containers, the PL will priortize the order based on project objectives. If necessary, allow the well to recharge overnight, but not more than one day, and continue with the remaining bottles.
10. The bailer and any equipment coming into contact of contaminated surfaces are cleaned.

4.4 Low-Flow Sampling

1. Measure groundwater level, then depth to bottom if needed. Decontaminate the sounder.
2. Set the pump inlet:

   Bladder Pump. When using a bladder pump, the pump itself is lowered into the water column. Attach the appropriate length and diameter of the tubing, so the blader pump intake is within the screened-interval at the depth determined during the pre-sample planning. Adjust for site conditions and record depth.

   Secure the airline to the pump controller. Connect the discharge line from the pump to the bottom intake of the flow-through cell of the water quality meter.

   Note. *Bladder pump pressures, refill, and discharge rates are adjusted to achieve the desired flow rates. Equipment operators should be thoroughly familiar with the operation of bladder pumps.*

   Peristaltic Pump. The pump remains at the ground surface, and tubing is lowered into the water column when using a peristaltic pump. Attach the appropriate length and diameter of the tubing, so the peristaltic pump intake is within the screened-interval at the depth determined during the pre-sample planning. Adjust for site conditions and record depth.

   Note. *Peristaltic pumps are limited in that water can be pumped to the surface from a maximum depth of approximately 25–30 feet*.

3. Start pumping and record time. The initial rate should be low enough to avoid drawing down the water table, increasing the rate while maintaining the water level. Low-flow sampling is achieved in the range of 100 mL/minute to 500 mL/minute.
4. If a drawdown of more than 4 inches or 1% of the water column, whichever is lesser, is observed, adjust the pumping rate to reduce the drawdown as much as possible. If the pump rate exceeds the well's recovery rate, the pump intake will have to be lowered as needed to accommodate the drawdown.
5. Once drawdown is stable, and water has begun to discharge from the flow-through cell, start recording water stabilization/quality parameters and depth to water measurements. Continue measurements until the water stabilization parameters meet criteria (Section 4.2.2 "Groundwater Parameters").
6. Disconnect the tubing from the inlet of the multimeter flow cell to begin filling the laboratory-supplied sample containers directly from tubing connected to the pump (See Section 4.7 "Filling Sample Containers").

7. If the well dewaters, collect samples after the well recharges to approximately 80 percent of its pre-purge volume.
8. In cases where recharge volume is insufficient to fill all containers, the PL will priortize the order based on project objectives. If necessary, allow the well to recharge overnight, but not more than one day, and continue with the remaining bottles.
9. The bladder pump is then removed and cleaned with all other downhole equipment. Similarly, the tubing is removed and discarded unless it is dedicated to the well.

4.5 Submersible Pump Sampling

1. Measure groundwater level, then depth to bottom if needed. Decontaminate the sounder.
2. When using a submersible motorized pump, the pump is lowered into the water column.
3. Secure the electrical line to the appropriate power supply and the discharge line from the pump to a marked container such as a tank, drum, or bucket. The container has markings to track the volume of water purged from the well.
4. Start pump and record time. The initial rate should be low enough to avoid drawing down the water table, increasing the rate while maintaining the water level. Purge rates are not defined for submersible sampling, but the rate cannot drop the water level if higher rates are used.
5. If a drawdown of more than 4 inches or 1% of the water column, whichever is lesser, is observed, adjust the pumping rate to reduce the drawdown as much as possible. If the pump rate exceeds the well's recovery rate, the pump intake will have to be lowered as needed to accommodate the drawdown.
6. Continue pumping until at least three well volumes have been removed.
7. Collect one set of water quality measurements from a fresh aliquot of sample after finished the well purging. Measurements are taken from a cup supplied with the multimeter.

   ***Note**. Some project work plans specify water quality measurements after each well volume. Consult the PL or FTL for the project specifications.*

8. Fill the laboratory-supplied sample containers (See Section 4.7 "Filling Sample Containers"). Typically, the a bailer is used to collect samples. However, if an appropriate tubing material is used and the pump can operate at less than 150 mL/minute, the samples can be collected directly from tubing connected to the pump.
9. If the well dewaters, collect samples after the well recharges to approximately 80 percent of its pre-purge volume.
10. In cases where recharge volume is insufficient to fill all containers, the PL will prioritize the order based on project objectives. If necessary, allow the well to recharge overnight, but not more than one day, and continue with the remaining bottles.
11. The pump is then removed and cleaned with all other downhole equipment such as tubing and electrical cables.

4.6 Temporary Well Sampling

Procedures used to purge groundwater from temporary wells differ from permanent wells because the well is installed for immediate sample acquisition, and the well is usually not developed as is done with permanent wells. Temporary wells include 1) PVC wells, with a slotted screen, installed using traditional drilling/hand-augering methods with/without a filter pack, or 2) a rigid rod and screen pushed, driven, or hammered into place to the desired sampling interval. Different manufacturers use proprietary products to install temporary wells, but their approach to sampling are similar.

In cases where the temporary well is sampled immediately after installation, purging is conducted primarily to mitigate installation impacts. In most cases, temporary well installation procedures disturb the existing aquifer conditions, resulting in increased turbidity. Therefore, purging aims to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.

The longer a temporary well/probe is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply, to the extent possible, standard permanent monitoring well, purging criteria to the well to return to representative aquifer conditions. The PL should determine appropriate purge parameters based on project requirements.

Sample collection times in formations with low hydraulic conductivity may exceed several hours, compared to several minutes in high to moderate conductivity formations.

1. Groundwater samples can be obtained in several ways:, but a bailer or peristaltic pump is typically used.

   Bailer or Mini-bailer. The water sample is retrieved by lowering a standard-sized or mini-bailer (depending on inside well diameter) until its immersed in groundwater and allowing the bailer to fill with water. The water recovered in the bailer is then decanted directly into the appropriate sample containers from the bailer tip or sample valve inserted at the check ball, opening the valve, and pouring the sample.

   Peristaltic pump. Groundwater samples can be collected by attaching a peristaltic pump to the tubing and collecting the sample from the tubing outlet.

2. After samples are collected, water levels may be measured. Allow enough time for groundwater to fill and reach static water level conditions. Measure groundwater level. Decontaminate the sounder.
3. Document results on the appropriate form, as specified by the project-specific work plans.

4.7 Filling Sample Containers

Use laboratory-supplied sample containers of the size/volume and containing preservatives (if required) specified in the project plans. Some preservatives are added after the sample is collected.

When collecting samples to analyze VOCs or GRO, collect those first. Fill the VOC sample vials slowly until a meniscus forms over the vial lip. Cap the vial and invert to ensure no air bubbles are present. If an air bubble is present, the vial will be opened, topped off with an additional sample, and capped. Recheck for bubbles. Do not dump the vial contents, or the preservative will be lost. If air bubbles are still present, the VOC sample vial will be discarded and a new vial used. The VOC sample vial filling procedure is repeated. If the sample is effervescing, filling a vial without bubbles may not be possible. In that case, submitting a vial with air bubbles may be acceptable if approved by the FTL. Laboratories are required to document whether containers have bubbles greater than pea-sized.

If other sample analyses are required, fill the other sample containers after filling the VOC/ or GRO sample vials. Fill each bottle to the base of the bottleneck. Care will be taken to avoid aerating the sample and not overfill bottles containing preservatives. All samples shall be appropriately preserved as described in the project plans. Each sample container to be submitted for analysis will be appropriately labeled per SWE-FSOP-002 (Field Sample Management).

When there is an insufficient of grounwater (limited recharge) the samples should be collected in an order of analysis specified by the FTL in coordination with the PL to meet project objectives. Altenately, fill containers in the following order.

1. Purgeable organic carbons
2. Purgeable organic halogens
3. Total organic halogens
4. TOC
5. Base neutrals/acid extractables
6. Total petroleum hydrocarbons
7. PCBs/pesticides
8. Total metals
9. Dissolved metals
10. Phenols
11. Cyanide
12. Anions
13. Ammonia
14. Preserved inorganics
15. Radionuclides
16. Non-preserved inorganics
17. Bacteria.

A clean 0.45-micron filter is attached to tubing connected to the positive-displacement pump and poured directly into the sample container to collect filtered samples. Samples collected without pumps can be poured into an unpreserved sample container and then pumped through the filter using a peristaltic pump. Hand pumps are commercially available as an alternative. Larger pore size filters can be used in series with the 0.45-micron filter to reduce suspended solids from the water.

4.8 Document Control

Sampling field forms should be completed in their entirety. If an entry is not applicable, indicate "n/a" (not applicable) or line out the entry.

After a task or project, all field documentation, including the field logbook, field datasheets, and electronic data, shall be scanned and placed on the server in the appropriate folder. All original documents shall be submitted to the PL and kept in the project file. See FSOP-001 (Field Documentation).

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

The values of the water quality parameter measurements and water depths must be compared to the previous event measurements to assess the reasonableness of the new data. If a water quality parameter measurement is inconsistent with the past measurement, then an instrument check of a calibration standard for the suspect parameter should be performed. If the calibration is out of specifications, the instrument should be repaired or replaced, the suspect parameter measurement should be evaluated for its usability, and a new measurement is taken unless the PL approves otherwise. For water levels, the measurement is repeated.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0 “Procedures”) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

U.S. Army Corps of Engineers, 2014. *Safety and Health Requirements. EM 385-1-1*. November 30

California Department of Toxic Substances Cotrol (DTSC), 2008. *Representative Sampling of Groundwater for Hazardous Substances, Guidance Manual for Groundwater Investigations.* February.

U.S. Environmental Protection Agency (USEPA), 2017. *Low Stress (low flow) Purging and Sampling Procedure for the collection of groundwater samples from monitoring wells*. September.

Passive Groundwater Sampling

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Approvals

Christopher Ohland — October 19, 2023

Christopher Ohland
SWE Quality Assurance Manager

Date

Steve Korbay — October 19, 2023

Steve Korbay
SWE Field Quality Control Manager

Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures

Rev 2, 10/19/2023: Revised to include additional detail to passive diffusion bag (PDB) sampling procedures and include PDB sampling guidance (USGS, 2001).

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to direct field staff in the proper techniques and documentation requirements to collect groundwater samples using passive techniques.

In general, passive groundwater sampling is performed by obtaining samples without purging the well before collecting samples. These samples are packaged and then submitted for laboratory tests that may include trace analyses of analytes. Therefore, In most instances, the laboratory performs sub-part per million tests. Thus, care must be taken to collect samples representative of the site groundwater and to minimize cross-contamination of the collected sample.

1.2 Scope

The scope of this SOP applies to field staff collecting groundwater samples using passive sampling techniques from temporary and permanently installed wells. The field staff may be employed by Ahtna or by a subcontractor. Trained environmental professionals will be engaged in or directly supervise the collecting and handling of environmental samples.

This SOP also provides per- and polyfluoroalkyl substances (PFAS) friendly procedures. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP, which are indicated by [PFAS Projects].

1.3 Responsibilities

Field Team. A Field Team is one or more individuals working together. The Field Team is responsible for the oversight of and/or collection of groundwater samples as specified in this SOP.

Field Team Lead (FTL). The FTL reviews project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current USACE EM-385-1-1 Safety and Health Requirements. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies, incidents, and actions to correct those. If the circumstance warrants, the FTL approves those actions or notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

HydraSleeve Sampler. The HydraSleeve™ groundwater sampler can collect a representative sample for most physical and chemical parameters without purging the well. It collects a whole water sample from a user-defined interval (typically within the well screen) without mixing fluid from other intervals. One or more HydraSleeves are placed within the screened interval of the monitoring well, and a period is allocated for the well to re-equilibrate. The sealed HydraSleeve can be activated at a later prescribed time for sample collection. HydraSleeve collects a sample with no drawdown and minimal agitation or displacement of the water column when activated. Once the sampler is full, the one-way reed valve collapses, preventing extraneous, non-representative fluid mixing during recovery (Section 4.4).

Passive Diffusion Bag Sampler. A passive diffusion bag (PDB) is a no-purge sampling technique that may be justified for use on wells that display little or virtually no recharge or for long-term monitoring during the operation and maintenance phase of remediation. The PDF is applicable for sampling a select list of VOCs only. A single PDB represents only 5 feet of the water column. (Section 4.3).

Snap Sampler. The Snap Sampler™ collects representative samples in situ without purging. It is effective for discrete interval sampling. It is used on wells 2 inches in diameter or greater (Section 4.5).

2.0 Relevant Documents

This SOP focuses on the most commonly used groundwater sample collection tasks and applications and should be used in conjunction with other applicable SOPs, including the following:

Standard Operating Procedures

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-101, Water Quality Measurements
- SWE-FSOP-102, Groundwater, and NAPL Measurements
- SWE-FSOP-801, Equipment Decontamination

Field Forms

- SWE-FFRM-004, Daily PFAS Sampling Checklist [PFAS Projects]
- SWE-FFRM-301, Groundwater Sampling
- SWE-FFRM-501, Depth Measurements
- SWE-FFRM-801, Equipment Calibrations

3.0 Equipment List

Multiple types of equipment can be used to sample groundwater. The Project Lead should determine the correct equipment based on site conditions and analyses to be performed.

Sampling Devices

- Passive Diffusion Bag Sampler
- Rigid Diffusion Sampler
- HydraSleeve Sampler
- Snap Sampler

Other Equipment/Supplies

- Chain of custody forms and custody seals
- Clean cooler
- Decontamination equipment and soap (i.e., Liquinox™), deionized (DI) water, and tap water

  [PFAS Project]: Reusable non-dedicated equipment will be rinsed with certified PFAS-free water before and after collecting each sample. If another water source is used, collect a water sample and run laboratory tests for PFAS before using that source.

- Electronic water level meter such as the Solinst Model 101 or equivalent
- Waterproof, indelible pens/markers in black or blue ink

  [PFAS Project]: Use ball-point pens. Do not use markers, felt pens, or pens with water-resistant ink.

- Field logbook

  [PFAS Project]: Field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Field forms

  [PFAS Project]: Record of field events will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard-cover notebooks are not acceptable. Field logbooks are permanently assigned to a specific project.

- Gel or bag ice (determine which is appropriate)

  [PFAS Project]: Ice in polyethylene bags

- Health and safety equipment, including safety glasses and nitrile/latex exam gloves as specified in the project-specific Health and Safety Plan
- IDW Labels
- Multi-meter (water stability/quality parameters)
- Meter calibration standards
- Oil/water interface probe, if non-aqueous phase liquid (NAPL) is expected
- Packaging tape

  [PFAS Project]: Use PFAS-free tape

- Sample bottles

  [PFAS Project]: Do not use glass, LDPE, or Teflon®-lined caps.

- Paper towels
- Sample Labels
- Tools to open wells

4.0 Procedures

Procedures are provided for:

- Pre-sampling tasks (Section 4.1)
- Preparing a well for collecting representative samples (Section 4.2)
- Sampling using three different devices (Section 4.3 to 4.5)
- Filling sampling containers (Section 4.6)
- Document control (Section 4.7)

4.1 Pre-Sampling Tasks

The Field Team should have the most recent groundwater levels and water quality data. That information is used to evaluate the reasonableness of the water level and water quality measurements of the current event. Unusual measurements should be verified.

Determine the intended placement of passive samplers in advance, considering the most recent water level measurement. Typically, the screen midpoint is used, or a depth is selected from the evaluation of multi-depth sampling. The PL shall ensure those depths are available to the Field Team.

Decontaminate and calibrate all instruments before obtaining field data according to SWE-FSOP-801 (Equipment Decontamination) and SWE-FSOP-107 (Equipment Calibrations). Equipment in contact with groundwater at one location must be decontaminated before reusing at another location.

> [PFAS Project]: Reusable non-dedicated equipment will be rinsed with certified PFAS-free water before and after collecting each sample. If another water source is used, collect a water sample and run laboratory tests for PFAS before using that source.

If NAPL (such as floating/heavier-than-water product) is suspected in the well, check for NAPL presence using an oil/water interface probe. If detected, record the presence and thickness of NAPL in the field notebook (SWE-FSOP-102. “Groundwater and NAPL Measurements”).

Before sampling, measure groundwater depths to assess the site's hydrogeologic conditions. Total depth, if needed, would be collected after the passive sample is collected. Measure the depth of groundwater in each well to within 0.01 feet. Measurements can be performed as one activity or individually when combined with the sampling effort. Ideally, depth-to-water measurements should be taken within one day. In practice, measurements should be taken within a few days but not longer than one week. The PL shall instruct the FTL if fieldwork is performed outside this guideline. Conditions that should trigger discussions are heavy rainfalls, tidal influences, excessive nearby groundwater extraction, or other unusual conditions.

4.2 Representative Samples

4.2.1 Purging

Passive samplers work on the principle of diffusion--chemical compounds dissolved in water move from areas of high concentration outside the sampler to the initially low concentration inside the sampler until equilibration is reached. Deciding where to place the sampler is crucial, but purging is unnecessary.

If samples other than those for VOC analysis are required, low-flow sampling should be considered an alternative method to replace passive sampling with active sampling (SWE-FSOP-401, Active Groundwater Sampling).

Equipment-specific techniques are described in Sections 4.3 through 4.5.

4.2.2 Water Quality Parameters

Water quality parameters may be measured if specified in the project work plans.

Water quality parameters are most commonly measured downhole using a clean, calibrated multimeter.

Measurements are taken downhole after the passive sampler is retrieved and containers for priority laboratory tests are filled. The multimeter probes are fed downhole to the screen's midpoint or alternate depth provided by the PL. Once positioned, allow the meter readings to stabilize. Unlike flow-thru cell measurements, no specification is defined for "stabilization." Typically, parameters are monitored until stable or fluctuation is minimal, then one set of parameters is recorded.

4.3 Passive Diffusion Bag Sampler

Passive diffusion sampling allows VOCs to diffuse from groundwater through a semi-permeable membrane into a deionized (DI) water-filled, closed sampler until VOC concentrations equilibrate under natural passive conditions from discrete intervals in the well screen.

A single-tether method is used to install multiple PDBs in a single well (Figure 1). This method requires using one tether and attachment rings, attaching the sample at the top and bottom, and installing a weight to the bottom of the tether.

The general procedures are outlined below:

- Fill Equilibrator™ (PDB) with DI water (install plug after sampler is filled). Equilibrators may come pre-filled by the supplying laboratory.
- Install at a prescribed depth within the well screen (location determined by project requirements); multiple samplers can provide a concentration/contaminant vs. depth profile.
- Leave in place for at least 1–2 weeks or longer. Be sure to check the project work plans. Some analytes require up to 30 days to equilibrate
- Remove PDB and fill sampling containers following Section 4.6.
- Discharge options consist of a "juice box" straw that allows filling a volatile organic analysis (VOA) vial from the bottom of the PDB or pouring from the fill port.

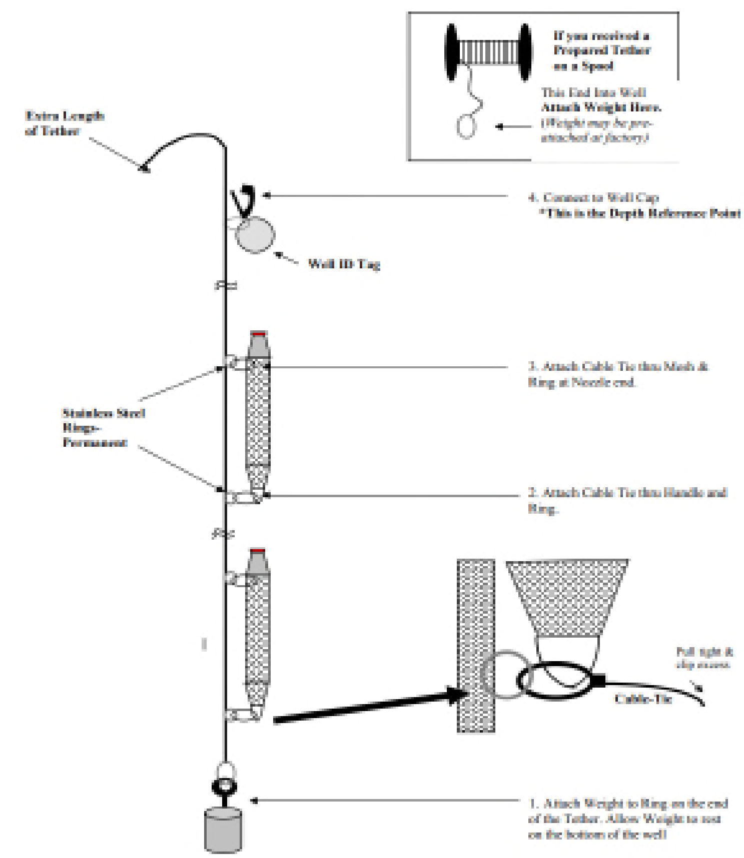

Figure 1. Typical PDB

4.3.1 Sampler Hardware Setup

- The hardware for each well in a sampling program will be custom-made by the PDB manufacturer or by field sampling personnel before the initiation of the field program.
- Each hardware kit should be labeled for each well and closely match the dimensions submitted to the manufacturer.
- If the sampler hardware is pre-constructed, open the hardware kit bag and carefully unwind the first few feet of cable or rope to expose the first PDB station (colored zip ties or metal clips) from which the PDB samplers will hang.

4.3.2 Deploying PDB Samplers

- Pre-assembled PDB hardware kits are available from manufacturers who construct the kit to the customer's specifications. If the hardware kit is to be assembled in the field, the FTL should provide the specifications for appropriate sample intervals and hardware placement.
- Clip the PDB sampler onto the station’s top and bottom retainer rings using the available zip ties and record and bag position.
- When deploying multiple samplers, start in the reverse order the PDBs will be retrieved, and continue attaching samplers to remaining station locations.

Note. Once a well has been profiled and a specific depth has been selected, only one PDB sampler is installed normally – the depth interval will be noted on the field instruction form. Check with the FTL for event-specific instructions.

- Record the relative position of each bag – they will be numbered in the order they will be retrieved (i.e., from top to bottom, #1, #2, and #n) – in other words, the first PDB sampler to be installed will have the highest number and the last PDB sampler will have the lowest number.
- Once the necessary PDB samplers have been connected to the hardware, carefully lower the hardware kit until the stainless-steel weight touches the well bottom.
- Confirm that the top clip (marker) roughly equals the top of casing and adjust as necessary to ensure a snug fit (slightly taught line) when the well cap is closed.
- Attach the end of the hardware line to the wellhead hanging device – make sure that the PDB sampler kit does not sag when the well cap is closed.
- Secure the well.
- Record the date and time the PDBs were deployed into the well.

4.3.3 PDB Sampler Retrieval

- Collect the appropriate VOA vials for the required VOC samples from the sampled wells (typically three 40 mL septa-sealed vials with HCl preservative).
- Measure and record the corrected depth to water from the top of casing to confirm that PDBs are completely submerged below the water level at the time PDBs are retrieved.
- Note the time and begin reeling the PDB sampler hardware line.
- Field personnel must include a station number for each sampler on the chain of custody.

****Important** - the contents of each bag must be transferred to the VOA vials immediately after PDBs are removed from the well and before addressing any other sampling-related issues to avoid losing volatile compounds to the atmosphere. The exposed bag time limit starts simultaneously once the first bag leaves the water. All samples shall be contained in the VOA vials within 15 minutes of the PDB leaving the water.

- Extract the PDB sampler(s) from the well, remove the sampler cap, and carefully pour the contents into VOA vials (preferably set up in a bottle holder), not over-agitating the bag or water.
- Apply the completed label to each VOA vial to avoid confusion later.
- Repeat until all PDB samplers have been removed and contents transferred.
- Field duplicate samples consist of two VOA vials filled from the same diffusion sampler. Fill two additional sets of vials if matrix spike and matrix spike duplicate samples are needed.
- Follow the above guidelines to reinstall new PDB samplers as scheduled (profile or single-bag scenario).
- Dispose of all used passive diffusion sample bags and components appropriately as hazardous or non-hazardous IDW.
- Decontaminate all reusable equipment according to project-specific requirements.

4.4 Rigid Sampler

4.4.1 Filling the Rigid Porous Sampler

Rigid porous polyethylene passive diffusion samplers (RPPs) (Figure 2). The RPPs are filled with de-ionized, analyte-free water, capped at one end, and a plug inserted into the other. They are pre-filled in a water-filled pouch to ensure air does not enter the pores. The RPP is placed in a mesh liner so that it may be attached to the deployment line with cable ties

4.4.2 Deploying the Rigid Porous Sampler

To deploy, cut open the outer bag with the red cap pointed up and the plug end down. Slip out of the bag, which you can then discard. Attach the RPP to the deployment line using cable ties. It’s very important to keep the red cap up and plug it down. Gently lower the sampler down the well, taking care not to jerk the line or hit the slides to avoid weeping from the walls of the sampler.

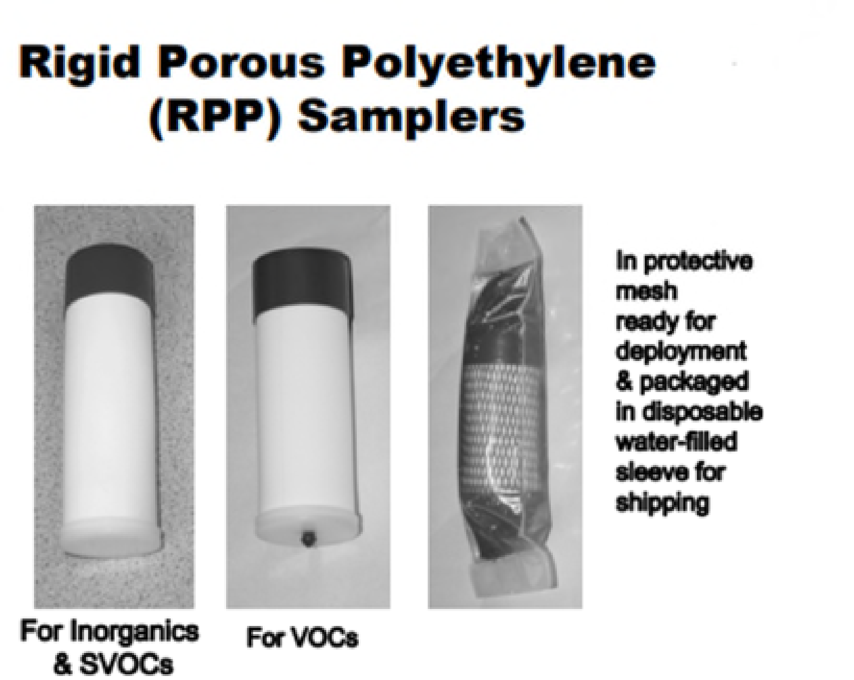

Figure 2. RPP Samplers

4.4.3 Retrieving the Rigid Porous Sampler

Use the same care when retrieving the samplers as deploying them. When the RPP appears at the top of the well, cut the cable ties holding the sampler to the deployment line, keeping the sampler in the same orientation. Cut away the cable ties that hold the mesh together at the sampler's top and bottom. Push down on the red cap through the mesh until the white plug is free of the mesh, still keeping it in the same orientation (cap up, plug down).

As soon as possible, pour the contents into your sample bottle. This is done by inverting the sample (plug end up), turning the plug out of the sample (do not squeeze the sampler!), and emptying the contents into your sample bottle. Cap your sample bottle, prepare for shipment to your lab, and discard the sampler. Some samplers use saran wrap to surround the RPP to help minimize leaking. If you are sampling for VOCs, the small red plug would be removed, and the contents carefully poured into a VOA vial to prevent too much exposure to the surrounding air.

4.5 HydraSleeve Sampler

4.5.1 Deploying the Single HydraSleeve(s)

1. Assemble the HydraSleeve per the manufacturer's field manual.
2. Lower the HydraSleeve device into the well using one of three techniques described below. Note: lowering the device displaces the water column, and some mixing of the column occurs. The diameter of the device and the rate at which the device is deployed into the water column affect the column mixing.
3. Three basic methods exist for holding a HydraSleeve in position as the well equilibrates.

   Top-Down Deployment (Figure 3). Measure the correct amount of suspension line needed to "hang" the top of the HydraSleeve(s) at the desired sampling depth (in most cases, this will be at the bottom of the sampling zone). The upper end of the tether can be connected to the well cap to suspend the HydraSleeve at the correct depth until activated for sampling. Note: For deep settings, it may be difficult to measure long segments of suspension line in the field accurately. Factory-prepared, custom suspension line, and attachment points can purchased.

   Bottom Deployment (Figure 4). Sound the well to determine the exact depth. Lower the weighted HydraSleeve into the well and let it touch the bottom. Very slowly (less than 0.5 feet per second), raise the sampler to the point where the check valve is at the depth at which the sample will be collected. Attach the suspension line to the top of the well to suspend it at this depth. (It is often easier to measure a few feet from the bottom of the well up to the sample point than to measure many feet from the top of the well down.) Alternatively, the sampler can be left on the bottom until the well re-equilibrates. For sampling, it can be very slowly pulled (< 0.5 feet per second) to sampling depth, then activated to collect the sample, and retrieved to the surface.

   Bottom Anchor (Figure 5). Determine the exact depth of the well. Calculate the distance from the bottom of the well to the desired sampling depth. Attach an appropriate length anchor line between the weight and the bottom of the sampler and lower the assembly until the weight rests on the bottom of the well, allowing the top to float at the correct sampling depth.

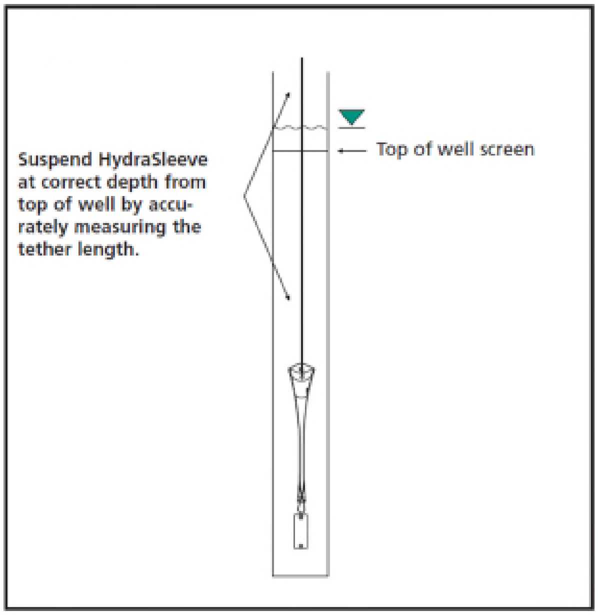

Figure 3: Top-Down Deployment

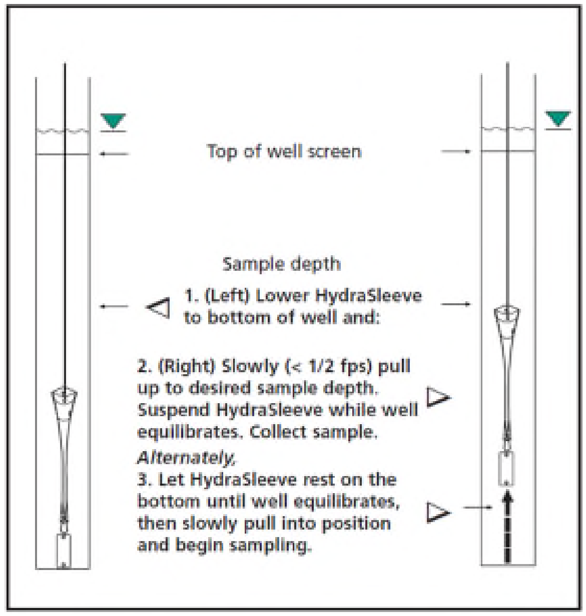

Figure 4: Bottom Deployment

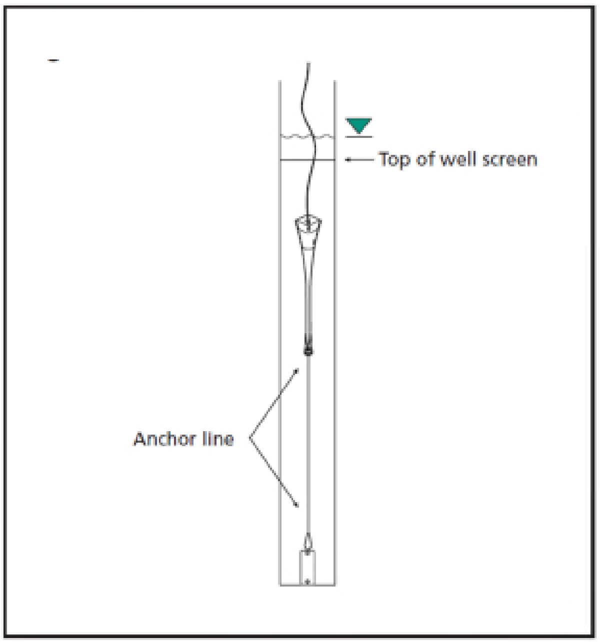

Figure 5. Bottom Anchor

4.5.2 Deploying Multiple HydraSleeves

1. Assemble the HydraSleeves per the manufacturer's field manual.
2. Lower the HydraSleeve device into the well using one of three techniques. Note: lowering the device displaces the water column, and some mixing of the column occurs. The diameter of the device and deployment rate into the water column affect the column mixing.
3. There are two methods for placing multiple HydraSleeves in a well to collect samples from different levels simultaneously:

   Attached to a Single Tether (Figure 6). To use three or more samplers simultaneously, attach them all to a tether for support to prevent the sampling string from pulling apart. The weight is attached to a single suspension line length and allowed to rest on the bottom of the well. The top and bottom of each HydraSleeve are attached to the tether at the desired sample intervals. Cable ties or stainless steel clips (supplied) work well for attaching the HydraSleeves to the line. Push one end of the clip between strands of the rope at the desired point before attaching the clip to the HydraSleeve.

Attached End-to-End (Figure 7). To place two or three stacked HydraSleeves for vertical profiling, use one of the methods described above to locate the bottom sampler. Attach the bottom of the top sampler to the top of the following HydraSleeve(s) with a carefully measured suspension cable length. Connect the weight to the bottom sampler. Note: if many HydraSleeves are attached to a tether, more weight may be required than with a single sampler.

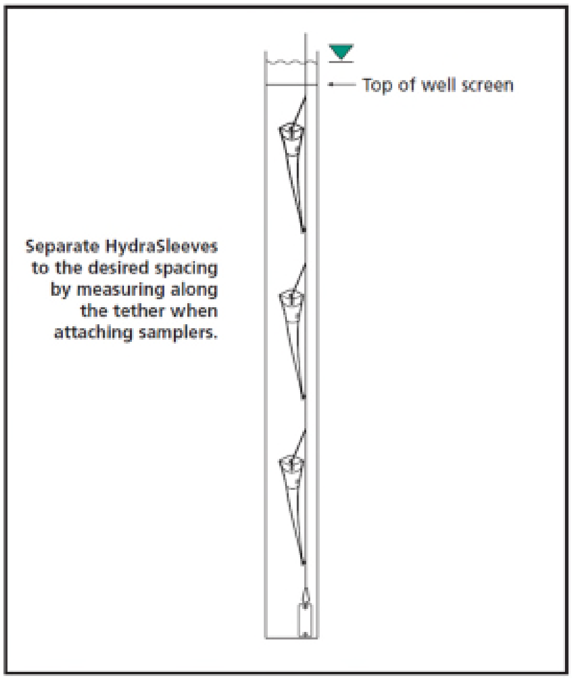

Figure 6: Tether

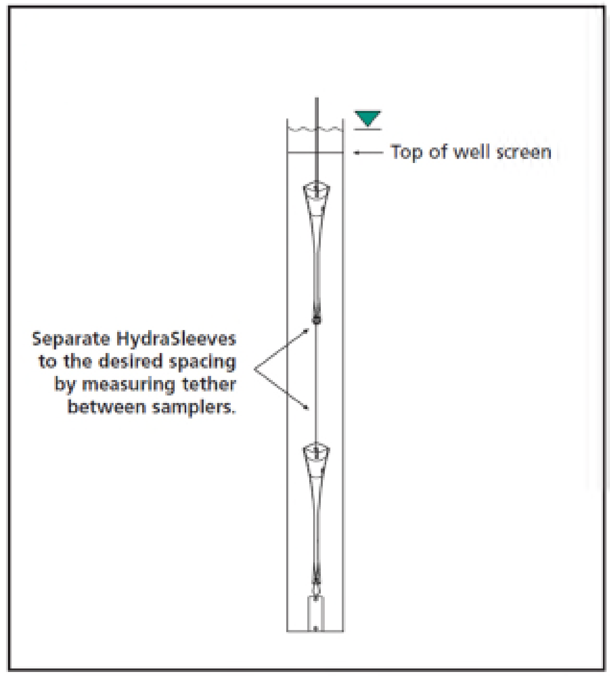

Figure 7: End-to-End

4.5.3 Filling the HydraSleeve(s)

The HydraSleeve must move upward at one foot per second or faster (about the speed a bailer is usually pulled upward) for water to pass through the check valve into the sample sleeve. The total upward distance the check valve must travel to fill the sample sleeve is about one to two times the length of the sampler. For example, a 24-inch HydraSleeve needs a total upward movement of 24 to no more than 48 inches to fill. The upward motion can be accomplished using one long continuous pull, several short strokes, or any combination that moves the check valve the required distance in the open position. A special technique is used for sampling low-yield wells (See “Sampling Low-Yield Wells” and Figure 9 below).

Continuous Pull (Figure 8). Pull the HydraSleeve continuously upward from its starting point at a constant 1 to 2 feet per second until full. This method usually provides the least turbid samples and is analogous to coring the water column from the bottom up.

Note: When using this method, the screen interval should be long enough so the sampler fills before exiting the top of the screen.

Short Strokes (Figure 9). Pull the sampler upward at about 1 to 2 feet per second for the length of the sampler and let it drop back to the starting point. Repeat the cycle 3 to 5 times. This method provides a shorter sampling interval than the continuous pull method (above) and usually reduces the turbidity levels of the sample below that of numerous rapid, short cycles (below). The sample comes from between the top of the cycle and the bottom of the sampler at its lowest point.

Rapid, Short Cycles (Figure 10). Cycle the HydraSleeve up and down using rapid, short strokes (6-inch cycle at a minimum of 1 cycle per second) 5 to 8 times. This method provides the shortest sampling interval. Dye studies have shown that when using this method, the sample flows into the check valve from along the length of the sampler and immediately above the check valve. The sample interval is from the bottom of the sampler at its lowest point in the cycle to the top of the check valve at the cycle's peak.

Sampling Low-Yield Wells (Figure 11). HydraSleeve provides the best available technology for sampling low-yield wells. When pulled upward after the well re-equilibrates, the HydraSleeve will collect a water core from the top of the sampler to about its own length above that point. The sample is collected with no drawdown in the well and minimal sample agitation. An optional top weight can be attached to compress the sampler in the bottom of the well if needed for an extremely short water column. With a top weight, the check valve is pushed down to within a foot of the bottom of the well.

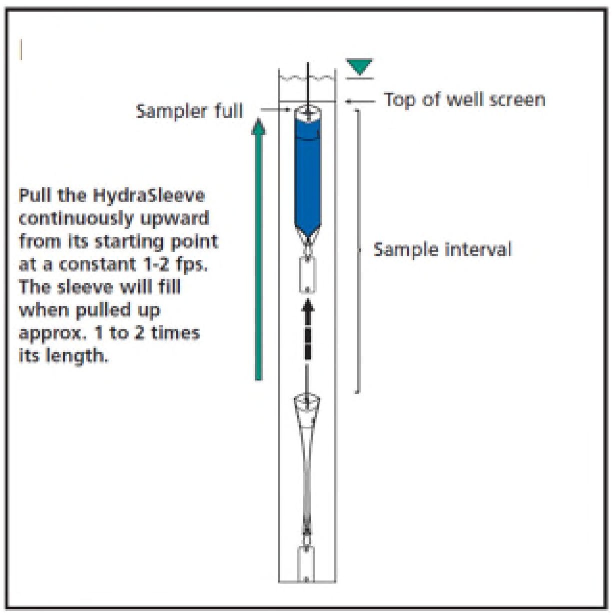

Figure 8: Continuous Pull

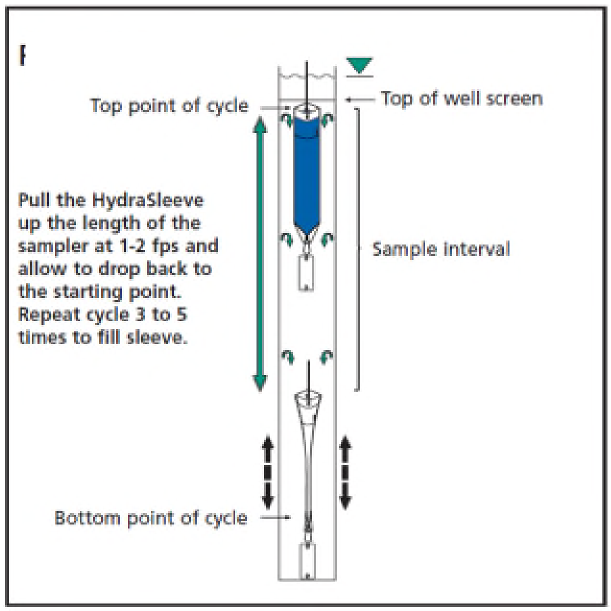

Figure 9: Short Strokes

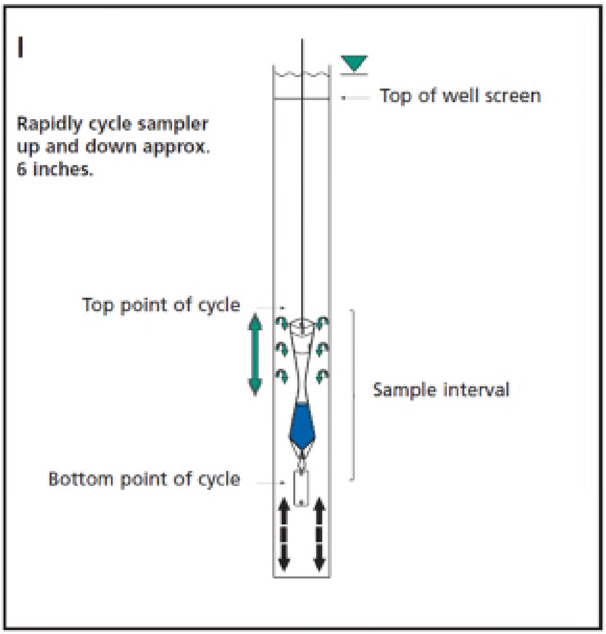

Figure 10: Rapid, Short Cycles

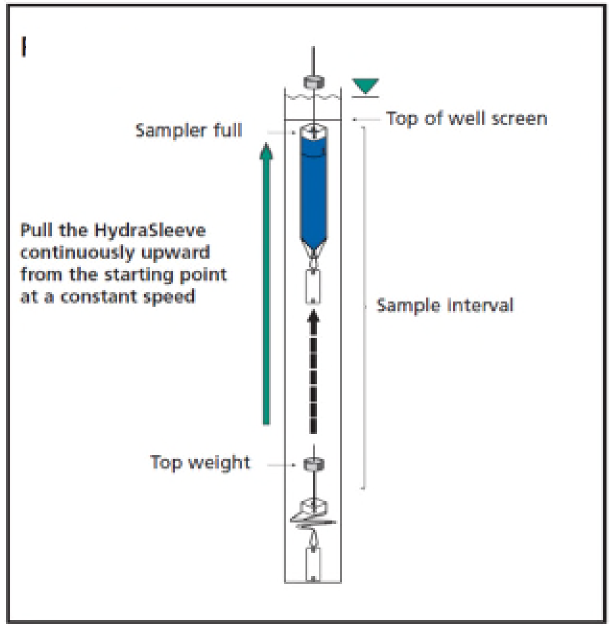

Figure 11: Sampling Low-Yield Wells

4.5.4 Sample Discharge

The best way to remove a sample from the HydraSleeve with the least amount of aeration and agitation is with the short plastic discharge tube included in the product packaging.

1. Squeeze the full sampler below the top to expel water above the flexible check valve.
2. Push the pointed discharge tube through the outer polyethylene sleeve about 3–4 inches below the white reinforcing strips.
3. Discharge the sample into the laboratory containers. Raising and lowering the bottom of the sampler or pinching the sample sleeve just below the discharge tube will control the flow of the sample. The sample sleeve can also be squeezed, forcing fluid up through the discharge tube, similar to squeezing a tube of toothpaste.

4.6 Snap Sampler

The Snap Sampler is a groundwater sampling device that employs a unique double-end-opening bottle with "Snap" sealing end caps. This dedicated, in-well equipment is deployed at the desired position in the screen interval with up to six Snap Samplers and six individual sampling bottles. The design allows collecting groundwater samples in dynamic equilibrium with the aquifer through a simple, no-purge/passive technique.

4.6.1 Preparing and Placing the Snap Sampler

The figures below show the typical processes for preparing the Snap Sampler (Figure 11) and placing it in the well (Figure 12).

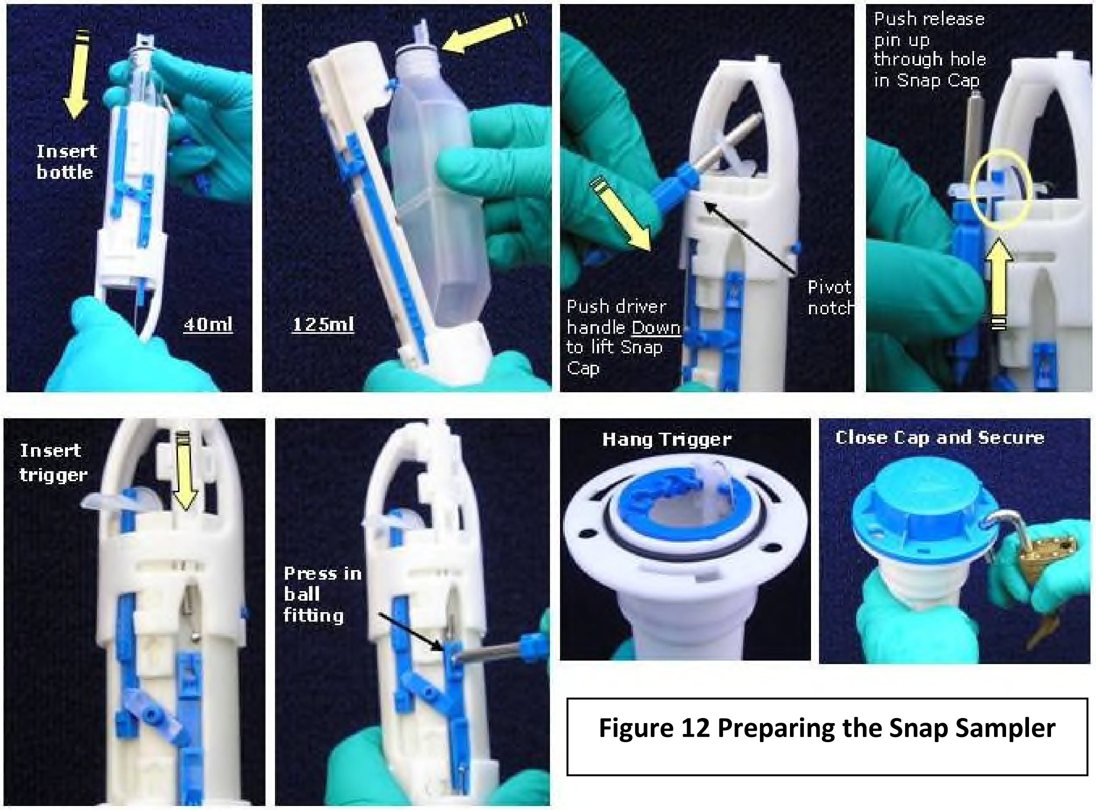

Figure 12 Preparing the Snap Sampler

4.6.2 Operating the Snap Sampler

1. Load the Snap Sampler with Snap Sampler bottles and set the Snap Caps into the open position.
2. Deploy the Sampler downhole with an attachment/trigger line and leave it in place to equilibrate for the prescribed period.
3. To collect samples, pull the mechanical trigger line or pressure up the pneumatic trigger system so the Snap Sampler bottles seal under the water surface.
4. The trigger releases Snap Caps that seal the double-ended bottles.
5. Once the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal.

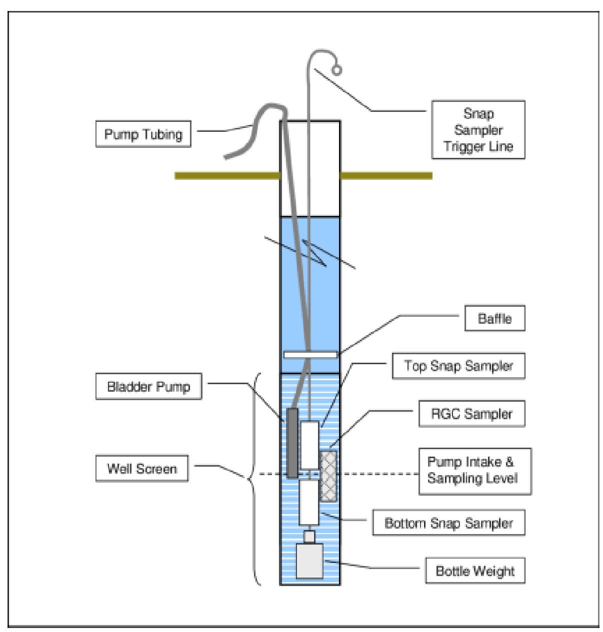

Figure 3: Placing the Snap Sampler in

4.7 Filling Sample Containers

Note. PDB samples are used for volatile organic compounds (VOCs) and gasoline range organics (GRO) laboratory analysis. Hydrosleeve and Snap samples may be used for other laboratory tests.

Use laboratory-supplied sample containers of the size/volume and containing preservatives (if required) specified in the project plans. Some preservatives are added after the sample is collected.

When collecting samples to analyze VOCs or GRO, collect those first. Fill the VOC sample vials until a meniscus forms over the vial lip. Cap the vial and invert to ensure no air bubbles are present. The vial will be opened and capped off with additional sample material if an air bubble is present. The flow rate should be reduced to limit bubble formation. Do not dump the vial contents, or the preservative will be lost. If so, use a new container. The vial will be immediately capped and rechecked for bubbles. If air bubbles are still present, the VOC sample vial will be discarded, and a new vial will be used. The VOC sample vial filling procedure is repeated until no air bubbles are seen. If the sample is effervescing, filling a vial without bubbles may not be possible. In that case, submitting a vial with air bubbles may be acceptable to the FTL. Laboratories are required to document whether containers have bubbles greater than pea-sized.

If other sample analyses are required, fill the other sample containers after filling the VOC/GRO sample vials. Fill each bottle to the base of the bottleneck. Care will be taken to avoid aerating the sample and not overfill bottles containing preservatives. All samples shall be appropriately preserved as described in the project plans. Each sample container to be submitted for analysis will be appropriately labeled per SWE-FSOP-002 (Field Sample Management)

For filtered samples, use a peristaltic or hand pump to push water through a clean 0.45-micron filter.

4.8 Document Control

Sampling field forms should be completed in their entirety. If an entry is not applicable, indicate “n/a” (not applicable) or line out the entry.

After a task or project, all field documentation, including the field logbook/notepad, field forms, and electronic data, shall be scanned and placed on the server in the appropriate folder. All original documents shall be submitted to the PL and kept in the project file. See FSOP-001 (Field Documentation).

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

The values of the water quality parameter measurements and water depths must be compared to the previous event measurements to assess the reasonableness of the new data. If a water quality parameter measurement is inconsistent with the past measurement, then an instrument check of a calibration standard for the suspect parameter should be performed. If the calibration is out of specification, the instrument should be repaired or replaced, the suspect parameter measurement should be evaluated for its usability, and a new measurement should be taken unless the PL approves otherwise. For water levels, the measurement is repeated.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0 "Procedures") and legibility. Errors and omissions should be explained, and revisions to an entry should be signed and dated by the FTL.

7.0 References

United States Geological Survey (USGS), 2001. User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells. Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance. Water Resources Investigations Report 01-4060.

Soil Sampling

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Approvals

Christopher Ohland
SWE Quality Assurance Manager

October 10, 2022
Date

Bruce Wilcer

SWE Field Quality Control Manager

October 10, 2022
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to provide field personnel with the techniques and requirements for the collection of surface and subsurface soil samples. These samples are then submitted for laboratory tests that may include trace analyses of analytes. Therefore, it is essential that care is taken to collect samples that are representative of the site surface and subsurface soil and minimize cross-contamination of the collected sample.

1.2 Scope

The SOP includes guidance for the performance, management, and completion of surface and subsurface soil sampling activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control. Surface and subsurface soil sampling are generally conducted by field personnel or drilling subcontractors on most projects and include the collection of disturbed and undisturbed samples manually and from stockpiles, excavation walls and floors, and drilling cores. Potential hazards related to drilling are addressed in project-specific Accident Prevention Plans and Site Safety and Health Plans.

Per- and polyfluoroalkyl substances (PFAS) friendly procedures are also provided in this SOP. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Project].

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for overseeing drilling activities according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the drilling subcontractor, logging geologic materials per SWE-FSOP-201, “Soil Classification,” and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness and accuracy of field documentation, and approval of the boring logs.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Aliquot – A portion of a larger whole, especially a sample taken for chemical analysis or other treatment.

Auger flight – A steel section (typically 5-feet long) of the auger attached to the auger string to extend the overall length as coring depth increases.

Composite sample – Two or more grab sub-samples (aliquots) taken from a specific soil and site at a specific point in time. The aliquots are collected and homogenized, and then a single average sample is collected from the mixture.

Decision Unit – The smallest volume of soil for which a decision is made based upon incremental sampling. A DU may consist of one or more sampling units (SUs).

Field Documentation – The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Forms – Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB. Each data entry field should have an entry or indicate that data for that field is not available or not required.

> [PFAS Project]: Record of field events will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard cover notebooks are not acceptable. Field logbooks are permanently assigned to a specific project.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

> [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

Field Notepad – A unbound notepad or loose-leaf paper with consecutively numbered pages.

Grab sample – A discrete portion or single aliquot collected from a specific location. Grab samples are not composited.

Hand auger – A stainless steel cylinder, commonly 3 to 4-inches in diameter and approximately one foot long, opens at both ends, with the bottom edge designed to twist into the soil and collect cuttings. The auger has a T-shaped handle (for hand operation) attached to the top of the auger by a metal rod extension(s).

Hand Trowel – A small scoop-shaped device, commonly stainless steel, operated with one hand to collect surface soil and place it into a sampling container.

Hollow stem auger – An auger with a hollow center designed to allow collection of soil samples using various tools without removing the auger.

Liner – A cylinder, generally made of plastic, brass, stainless steel, or Teflon placed inside a split spoon or auger to collect soil samples.

[PFAS Project]: For purposes of PFAS sampling, liners will be made of PVC, acetate or equivalent non-PFAS material.

Incremental Sampling Methodology (ISM) – A sampling method used to determine an average concentration of contaminants representative of soil within a defined area (decision unit) typically used in surface soil, stockpiles, and excavation pits.

Sampling Unit – A volume of soil from which increments are collected to determine an estimate of the mean concentration for that volume of soil.

Shelby tube – A cylindrical sampling device, generally made of steel, driven into the subsurface soil through the hollow stem auger or hand auger device with a slide hammer. The tube, once retrieved, may be capped and the undisturbed soil sample extruded in the laboratory before analysis.

Split spoon sampler – A cylindrical sampling device generally made of steel, which fits into a hollow stem auger. The split spoon is separated lengthwise, which allows the sample to be retrieved by opening (“splitting”) the spoon.

Surface soil – In general, soil extends from the surface to 6–12 inches below ground surface (bgs). However, each investigation's project-specific plans and data quality objectives should be reviewed to confirm the appropriate interval. Note: surface soil may reside under a paved surface.

Shallow subsurface soil – In general, soil that extends from approximately 12 inches bgs to a depth usually at which sample collection using manual collection methods becomes impractical (commonly around 2 feet bgs). However, each investigation's project-specific plans and data quality objectives should be reviewed to confirm the appropriate interval.

Subsurface soil – In general, soil deeper than 2 feet bgs, including material located above bedrock or any other consolidated material. However, each investigation's project-specific plans and data quality objectives should be reviewed to confirm the appropriate interval.

TerraCore® (Or EnCore®) sampler – A coring device that allows a specific quantity of soil to be collected (e.g., 5 grams and 25 grams) for volatile organic compounds (VOC) and total petroleum hydrocarbon (TPH) gasoline range organics (GRO) analyses. This device has a tight-fitting cap that seals with an O-ring.

2.0 Relevant Documents

This SOP focuses on the oversight and documentation of soil sampling activities and should be used in conjunction with other applicable SOPs.

Field SOPs

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-407, Incremental Sampling Methodology
- SWE-FSOP-801, Equipment Decontamination
- SWE-FSOP-802, Investigation Derived Waste Management

Field Forms

- SWE-FFRM-004, Daily PFAS Sampling Checklist [PFAS Projects]

3.0 Equipment List

The following items are typically used for sampling but do not include all types of equipment that may be used. Before mobilizing for fieldwork, the necessary equipment must be identified based on the sampling type.

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation

  [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Waterproof, indelible pens/markers in black or blue ink

  [PFAS Project]: Ball-point pens: do not use markers, felt pens, or pens with water resistant ink

- Sampling gloves
- Laboratory-supplied sample containers, preservatives, labels, chain of custody, custody seals, and temperature blanks
- Ice (gel or bag ice, determine which is appropriate)
- Zip-top plastic bags
- Stainless steel mixing bowls, pans, or trays
- Decontamination equipment and supplies (e.g., wash/rinse tubs, brushes, Liquinox™, plastic sheeting, paper towels, sponges, garden-type water sprayers, large plastic bags (minimum 0.85 mils), potable water, distilled water, or deionized water)
- Survey stakes, flags, or whiskers
- Personal protective equipment (PPE)
- TerraCore™ (or EnCore™) samplers if VOC or TPH-GRO analyses are needed. See Section 4.3.5 for Terra Core™ and En Core™ sampling steps.

Refer to project work plans to confirm equipment required for the specific sampling activity. This may include but is not limited to various field forms, sample containers, incremental sampling devices, and sample homogenizing equipment.

3.1 Manual (Hand) Sampling

- Trowel, shovel, pickax, mattock, or other excavating tools
- Hand auger with extension rods, as necessary
- Toolkit

3.2 Split Spoon or Shelby Tube Sampling

- Drill rig equipped with hollow stem augers and a drop hammer
- Split spoon or Shelby tube samplers (at least two)
- Split spoon liners, as necessary
- Sampling tube basket or spring retainers for loose soil
- Toolkit

3.3 Continuous Sampling

- Drill rig equipped with direct-push capabilities and pushrods or core barrel assembly that advances in front of the auger cutting head
- Enough drill rod liners for the planned number of sampling intervals
- Hook-blade utility knife to cut the liners (drillers may have a cutter on the rig)
- Basket retainers and caps for the liner ends for loose soil
- Toolkit
- Boring log forms

4.0 Procedures

Procedures are provided for:

- Pre-Field Tasks (Section 4.1)
- Retrieval Techniques (Section 4.2)
- Sample Collection (Section 4.3)

4.1 Pre-Field Tasks

Before sample collection, follow these general steps:

- Inspect the area to confirm work can be performed safely and there are no potential sources of field contamination (e.g., debris, wind-blown dust, etc.)
- Decontaminate all non-disposal sampling equipment according to SWE-FSOP-801 (Equipment Decontamination).

    [PFAS Project]: Dedicated or disposable equipment should be rinsed with certified PFAS-free water. If another source of water is used, collect a water sample and run laboratory tests for PFAS before using that source.

- Confirm that any disposable sampling equipment is clean and stored correctly before use.
- Don the appropriate PPE, as specified in the SSHP.
- Determine the sample collection locations based on the project goals and work plan specifications.

4.2 Retrieval Techniques

4.2.1 Manual Retrieval

Manual retrieval methods are commonly used to collect surface and shallow subsurface soil samples using hand tools such as stainless steel trowels, shovels, picks, etc. Surface soils generally include the interval from the ground surface to 6 to 12 inches bgs. However, project-specific plans and data quality objectives for the investigation should be reviewed to confirm specific intervals. The shallow subsurface interval may be considered to extend from approximately 12 inches bgs to a site-specific depth at which sample collection using manual collection methods becomes impractical (commonly around 2 feet bgs). For manual sampling, follow these general steps:

- Ensure that the sampling area is safe for entry. If the sample is to be collected from within an excavation, ensure that the excavation meets all criteria for safe entry.
- Use hand tools to access the depth required for sampling. If using a shovel or hand auger, place the soil cuttings on plastic sheeting or as specified in the work plan. If possible, lay the cuttings in order of depth.
- When collecting the sample, collect soil from a freshly exposed surface.
- Collect samples for VOC and TPH-GRO analyses first.

4.2.2 Hand Auger Sampling

Hand augers may be used to collect soil samples in the surface and shallow subsurface intervals as a discrete sampling activity or during initial borehole advancement when using a drill rig.

- Typically, a 3-inch stainless steel auger with cutting heads is used.
- The auger is advanced to the specified depth, and the contents are transferred to a homogenization container for processing.
- When collecting samples for analysis, hand auger holes should be advanced one auger length at a time until the sample depth is achieved.
- When the sample depth is reached, the auger used to advance the hole should be decontaminated or removed and a clean auger attached. In the field logbook, record the depth that the clean auger is advanced during sample collection.
- Because the auger may scrape material from the sides of the auger hole or material may slough into the bottom of the hole when the auger is extracted, judgment must be used to determine how much material in the top and bottom of the auger is not a representative sample and should be discarded.
- If collection of samples for VOC analysis is required, they should be obtained directly from the auger before contents are emptied, if possible.
- The entire hand auger assembly must be decontaminated before use when moving to a new sampling location.

4.2.3 Backhoe Sampling

Backhoes may be used to collect surface and shallow subsurface soil samples, most commonly from trenches and other excavations where manual sampling directly from an excavated surface is not feasible or safe.

- Samples may be obtained from the trench wall using a scoop on an extension or directly from the auger when it is brought to the surface.
- Smearing is an important issue to consider when sampling with a backhoe. It is advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample to ensure representativeness. Paint, grease, and rust must be removed, and the auger decontaminated before sample collection.
- When collecting the sample, obtain material beneath the surface in the center of the auger in order to avoid incorporating sloughed material in the sample.
- When collecting for VOC analysis, obtain samples directly from subsurface material in the auger.
- The reusable sampling tools must be decontaminated before use when moving to a new sampling location.

4.2.4 Split Spoon Sampling

Subsurface soil samples may be collected from soil recovered from a split spoon sampler when drilling with a hollow stem auger drill rig. For sampling from this device, follow these general steps:

1. Remove any pavement or sub-base material obstructing access to subsurface soil from an area twice the diameter of the drill bit, as necessary.
2. Ensure that the drill rig and all tooling are decontaminated before drilling.
3. Set up the drill rig with the hollow stem auger, the cutting head, and the center rod. Drill to the first sample depth.
4. As soil is brought to the surface with the auger flights, periodically remove these cuttings from the area specified in the work plan.
5. When the sample depth is reached, remove the center rod/cutting head assembly and deploy the split spoon sampler. Insert a liner(s) before sampler deployment, as necessary.
6. With the sampler shoe at the ground surface in the sample location, mark the center rod in 6-inch increments to allow blows to be counted.
7. Drive the sampler using the rig hammer. Use a full 30-inch drop as specified by the ASTM Method D-1586. Record the number of blows required to drive the spoon through each 6-inch increment.
8. Cease driving upon reaching the full sampler length or refusal. Refusal is when little to no progress is made for 50 hammer blows.
9. Pull up the center rod and sampler and remove the sampler from the drill rods.
10. Open the sampler to access the soil, careful not to disturb the soil.
    - If using a stainless steel liner(s), slide the liner from the sampler without disturbing the soil and seal the ends. Wipe the outside of the sealed liner with a paper towel and mark the depth on the outside of the liner with a marker.
    - If using an acetate liner that must be opened, cut twice along the length of the liner using a hook-blade utility knife. Typically, a ground cover should be placed in the working area so that soil unsettled from the sampler does not fall to the ground.

4.2.5 Direct-Push Soil Retrieval

Subsurface soil samples may be collected from a dual-tube sampler or a single rod sampler when using a direct-push drill rig or sonic drill rig, or a Shelby tube sampler when using a hollow stem auger drill rig. Plastic liners may be used to allow for soil removal from the sampler.

For sampling from these devices, follow these general steps:

1. Ensure that the drill rig and all tooling are decontaminated before drilling.
2. Drill to the first sample depth.
3. When the sample depth is reached, remove the drive tooling and deploy the sample barrel with a liner and a drive tip.
4. Advance the sample barrel through the desired sample interval and retrieve the sample by retrieving the rods.
5. Retrieve the soil by sliding the liner from the sample barrel. The liner may need to be removed using a hydraulic extruder.
6. Wipe the outside of the sealed liner with a paper towel and mark the depth on the outside of the liner with a marker.
7. Open the sampler to access the soil by cutting twice along the liner length using a hook-blade utility knife. Typically, a ground cover should be placed in the working area so that soil unsettled from the liner does not fall to the ground.

4.3 Sample Collection

For all soil samples, follow these general steps:

1. Remove bits of vegetation and large gravel from the sample as these items are not analyzed and reduce the available sample volume for analysis.
2. Take care to prevent cross-contamination and misidentification of samples.
3. Properly label the sample according to SWE-FSOP-002 (Field Sample Management).
4. Record the sample location (horizontal and vertical position), the sample date and time, and any other applicable information in the field notebook and on any applicable sampling forms before moving on to another sampling location. Note that samples collected from a soil recovery device during drilling should be collected from a discrete (short) depth interval.
5. Decontaminate any reusable sampling equipment according to the SWE-FSOP-801 (Equipment Decontamination) before moving on to another sampling location.
6. Properly package and ship all samples according to SWE-FSOP-002 (Field Sample Management).
7. Samples collected for VOCs/TPH-GRO shall be collected first, with the least disturbance possible, and immediately preserved. The collection should be performed using a TerraCore, EnCore, or equivalent sampler (defined in the project work plan) to collect a pre-determined volume. Place samples directly into a laboratory-supplied jar/vial and preserve them.
8. Samples submitted for other analyses are collected after soil is homogenized. Collect a non-volatile grab sample using a sample spoon or gloved hand and place the soil into a re-sealable plastic bag or bowl/pan/tray to homogenize the soil. Place the homogenized soil directly into a laboratory-supplied jar and preserve it as directed in the project work plan.

9. Make notes on the boring log regarding the soil characterization and geologic features, including any staining or odors (ensure no inhalation hazard exists). See SWE-FSOP-201 (Soil Classification). Note that samples should generally be collected before the characterization of soil to preserve the integrity of the volatile samples.
10. Wipe down the jar threads to remove any bits of soil and close the jar with the lid, and wipe the outside of the jar using a paper towel or other clean, dry wipes.
11. Label the sample container with the appropriate information; typically, use a label with waterproof adhesive, or if not, secure the label with clear tape.
12. Place the sample container in the shipping container, typically a chilled cooler, and proceed with further sampling.
13. When sampling is complete, all reusable downhole/sampling equipment and any drill rig components that may have come in contact with contaminated soil should be decontaminated before next use.

For specific types of sampling, follow the steps outlined in the following sections.

4.3.1 Discrete Sampling

Typically, discrete sampling is used unless otherwise dictated for the specific project. The locations and depths where discrete samples are collected should be explained in a site-specific work plan.

4.3.2 Composite Sampling

Composite sampling may only be conducted if previously approved in a site-specific work plan. If possible, coordinate with the testing laboratory if laboratory composting is possible.

Composite samples should have equal aliquots of soil collected as discrete samples from all sub-locations. If composite samples are necessary, aliquots of volatile samples are collected directly into laboratory-supplied jars and preserved immediately according to directions from the laboratory. Aliquots of non-volatile samples should be homogenized before placing into laboratory-supplied jars.

4.3.3 Incremental Sampling Methodology

ISM sampling may only be conducted if previously approved in a site-specific work plan. The method uses primary, replicate, and triplicate samples of the decision unit collected from many (30–50) sub-samples (aliquots) to create a statistically valid result. See SWE-FSOP-407 (Soil Incremental Sampling Methodology). The ISM sampling approach shall be conducted following the Interstate Technology & Regulatory Council (ITRC) Incremental Sampling Methodology Guidance (ITRC, 2012).

ISM sampling is similar to a composite sample in that equal aliquots of soil are collected in each gridded or celled decision unit (grid/cell dimensions to be determined based on decision unit size), using a random number generator to establish random planer and depth coordinates. A duplicate and triplicate sample should be collected using the same techniques as the primary sample to verify that the ISM sample truly represents the decision unit. Care should be taken to ensure triplicate samples are not collected from co-located or adjacent locations.

4.3.4 Soil Sampling for Physical Tests

Soil sampling for physical tests may be required to support geotechnical or hydraulic analyses. Tests may include compaction, shear analysis, porosity, permeability, grain size analysis, etc. Many soil physical tests require complete intact samples remaining in various size liners. Ends of liners should be capped to preserve the soil matrix integrity, and the sample transported to the laboratory for analysis. Before laboratory analysis, the soil should not be removed from the sampler liner.

4.3.5 VOC Coring Devices

Use TerraCore™, EnCore™) or equivalent devices to sample for VOC and TPH-GRO analyses

Terra Core® Sampler

1. Have ready a 40ml glass VOA vial containing the appropriate preservative. With the plunger seated in the handle, push the Terra Core®.
2. Wipe all soil or debris from the outside of the Terra Core® sampler. The soil plug should be flush with the mouth of the sampler. Remove any excess soil that extends beyond the mouth of the sampler.
3. Rotate the plunger that was seated in the handle top 90° until it is aligned with the slots in the body. Place the mouth of the sampler into the 40 ml VOA vial containing the appropriate preservative and extrude the sample by pushing the plunger down. Quickly place the lid back on the 40ml VOA vial.

Step 1

Step 2

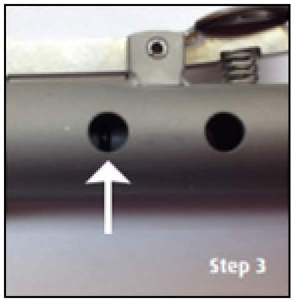
Step 3

Unless otherwise specified in the project work plans, Terra Core samplers used 5 grams of soil for each VOA vial per EPA Method 5035. Each Terra Core sampler is used once per sample.

En Core® Sampler

1. Label the En Core® sample envelope. Tear open the envelope. Hold the coring body and push the plunger rod down until the small o-ring rests against the tabs.
2. Depress locking lever on En Core® T-handle. Place coring body, plunger end first, into the open end of T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist coring body clockwise to lock pins in slots. Check to ensure En Core® sampler is locked in place. The sampler is ready for use.
3. Turn T-handle with T-up and coring body down. This positions the plunger bottom flush with the bottom of the coring body. Using T-handle, push the sampler into the soil until the coring body is full. When full, a small o-ring is centered in the T-handle viewing hole. Remove the sampler from the soil. Wipe excess soil from the coring body exterior.
4. Cap coring body while it is still on T-handle. Push cap over a flat area of ridge and twist to lock the cap in place. Cap must be seated to seal the sampler.

5. Remove the capped sampler by depressing the locking lever on T-handle while twisting and pulling the sampler from T-handle.
6. Lock plunger by rotating the extended plunger rod fully counter-clockwise until wings are firmly against tabs.
7. Return full En Core® Sampler to zipper bag, seal and store in a cooler at 4°C.



5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for soil sampling and field documentation review will be performed by the FTL or PL to check that procedures and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

6.0 Documentation Review

The FTL is responsible for daily review of the activities performed at the site and fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

American Society of Testing and Materials (ASTM) Method D-1586.

Interstate Technology & Regulatory Council (ITRC), 2012. *Incremental Sampling Methodology Guidance*. February.

Aquifer Testing

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Christopher Ohland
SWE Quality Assurance Manager

12/16/2022
Date

Bruce Wilcer
SWE Field Quality Control Manager

12/16/2022
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Original release

Table of Contents

1.0 Introduction

1.1 Purpose

This Standard Operating Procedure (SOP) establishes guidelines and procedures for conducting aquifer testing. Proper testing guidelines and procedures are necessary to effectively evaluate aquifer parameters and characteristics. The project work plans will provide additional specific aquifer testing procedures and requirements.

1.2 Scope

The scope of this SOP applies to field staff performing aquifer testing activities. The field staff may be employed by Ahtna or by a subcontractor. Trained environmental professionals will be engaged in or directly supervise the subcontractors' aquifer testing procedures.

Per- and polyfluoroalkyl substances (PFAS) friendly procedures are also provided in this SOP. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which is indicated by [PFAS Projects].

1.3 Responsibilities

Field Team. A Field Team is one or more individuals working together. The Field Team is responsible for overseeing and performing aquifer testing activities as specified in this SOP.

Field Team Lead (FTL). The FTL reviews project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current USACE EM-385-1-1 Safety and Health Requirements. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies, incidents, and actions to correct those. The FTL approves those actions or, if the circumstance warrants, notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Aquifer Test. Physical test to determine the hydrologic characteristics of confined or unconfined aquifers. Slug, specific capacity, step-drawdown, and constant rate pumping tests are commonly used testing methods.

Bailer. A bottom-filling cylindrical tube with a check valve at the bottom.

Bladder Pump. A positive-displacement pump is used to pump groundwater to the surface from most depths. A bladder pump can be small enough to pump water from wells as small as 3/4-inch in diameter.

Cone of Depression. A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone around a well from which water is being withdrawn.

Constant Rate Pumping Test. Aquifer test involving discharging water at a constant rate from a well by pumping and monitoring the corresponding water level drawdown. The recovery of water levels in the well may also be monitored after pumping has terminated (recovery test). Water level monitoring during a pumping and recovery test commonly includes the pumping well and one or more nearby observation wells. In certain instances, observation wells are unavailable, and water level monitoring is limited to only the pumping well.

Hydraulic Conductivity (K). A quantitative measure of the ability of a porous material to transmit a fluid. It is also defined as the volume of water flowing through a unit cross-sectional area of porous material per unit of time under a unit hydraulic gradient (l/t).

Observation Well. A non-pumping well used to observe the groundwater levels during pumping testing.

Peristaltic Pump. A negative air pressure pump used to draw groundwater to the surface. These pumps can be used if the depth to water is less than approximately 25 feet.

Potentiometric Surface. The surface defined by water levels from multiple wells that penetrate an aquifer or hydrogeologic unit. Also, a map of the hydraulic head of an aquifer.

Pressure Transducer and Data Logger. An electric sensor that measures hydrostatic pressure to determine depth below the water level. The data logger can store periodic water level measurements for later recall and data evaluation.

Recovery. The time rate of return to the static water level during a slug test or after cessation of pumping.

Saturated Thickness (b). For unconfined aquifers, the interval between the water table and the base of the unconfined water-bearing unit. For confined aquifers, the interval between the base of the upper confining unit and the top of the lower confining unit.

Slugging Rod - A large metallic or PVC rod (or cylinder) of known volume lowered into the well to displace the water during a slug test. Sometimes called a "pig.”

Slug Test. Type of aquifer test completed by instantaneously changing the water level in a well by adding, removing, or displacing a known volume of water and then monitoring the water level recovery in the well.

Specific Capacity (C). Discharge per unit of drawdown in a pumping well (Q/s).

Specific Capacity Test. Short-term single-well pumping test useful in highly transmissive units which preclude slug testing.

Specific Yield (Sy) - The ratio of the volume of water that saturated soil or rock will yield under gravity per unit volume of the saturated soil or rock. Specific yield is dimensionless.

Step-drawdown test. Test to estimate well performance, determine a sustainable optimum pumping rate for the well, and estimate aquifer properties, well loss, and well efficiency. The test is conducted by pumping the well at several successively higher rates and measuring the corresponding water level drawdown.

Storage Coefficient or Storativity (S) - The volume of water an aquifer releases from or takes into storage per unit area of aquifer, per unit change in head. The storage coefficient is dimensionless.

Submersible Pump. A positive-displacement pump is used to pump groundwater to the surface.

Transmissivity (T) - A quantitative measure of the ability of an aquifer to transmit water. It is the product of hydraulic conductivity and saturated thickness ($K \times b$).

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

Water Level - The position of the air-water interface in a well. The water level is usually measured as the depth to the water from a measuring point (such as the top of the outer protective well casing) by using a weighted measuring tape or electric sounder.

Water Table - The saturated zone surface at which the pore water pressure equals atmospheric pressure. The water table is the same as the potentiometric surface for an unconfined aquifer.

Wellhead Flow Meter - A meter installed in the water discharge line near the wellhead to measure the discharge (in volume/time) of water by the mechanical pump and controlled by the flow regulator.

2.0 Relevant Documents

This SOP focuses on the aquifer testing tasks and applications and should be used in conjunction with other applicable SOPs, including the following:

Standard Operating Procedures

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-101, Water Quality Measurements
- SWE-FSOP-102, Groundwater and NAPL Measurements
- SWE-FSOP-602, Groundwater Well Development
- SWE-FSOP-801, Equipment Decontamination
- SWE-FSOP-802, IDW Management

Field Forms

- SWE-FFRM-406, Aquifer Constant Rate Test
- SWE-FFRM-407, Aquifer Step Rate Test
- SWE-FFRM-501, Water Level/NAPL Measurements
- SWE-FFRM-801, Equipment Calibration

3.0 Equipment and Materials List

Multiple types of equipment can be used to complete aquifer testing. The correct equipment to use should be determined by the PL-based onsite conditions and analyses to be performed.

Materials used during aquifer testing must not absorb, desorb, or leach contaminants of concern. The materials used must be resistant to chemical and biological degradation.

Downhole Well Equipment

- Slugging Rod
- Bailer
- Bladder Pump and associated controller
- Peristaltic Pump
- Submersible Pump
- Electronic water level meter such as the Solinst Model 101 or equivalent
- Pressure transducers

    [PFAS Projects]: Surfaces in contact with well internal components or groundwater (e.g., bailers) should not contain Teflon® or other PFAS-containing material.

Other Equipment/Supplies

- Decontamination equipment including soap (i.e., Liquinox™), de-ionized and tap water
- Waterproof, indelible pens/markers in black or blue ink

    [PFAS Project]: Use ball-point pens. Do not use markers, felt pens, or pens with water-resistant ink.

- Field logbook

    [PFAS Project]: Field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and cover can be used.

- Field forms

    [PFAS Project]: Record of field events will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard-cover notebooks are not acceptable. Field logbooks are permanently assigned to a specific project.

- Graduated cylinder for checking flow rates
- Health and safety equipment, including safety glasses and nitrile/latex exam gloves as specified in the project Health and Safety Plan
- IDW Labels
- Meter calibration standards
- Multimeter with flow-through-cell or cup
- Paper towels
- Purge water storage (drums, tanks, etc.)

- Timing device
- Tools to open wells
- Vehicle battery (or external power supply) to power pump with pump controller

4.0 Procedures

This section contains responsibilities, requirements, and procedures for conducting aquifer testing. Slug, specific capacity, and pumping tests are commonly used testing methods to determine the hydrologic characteristics of confined and unconfined aquifers. Consequently, these methods are covered in this section.

4.1 Preparation

All aquifer testing to be conducted at a site must incorporate and be tailored to the following:

- Known or expected site-specific conditions
- Targeted parameters to be evaluated
- Analysis methodology(ies) to be conducted with the test data

Consequently, these factors must be considered, and the tests must be designed well before developing the project work plans and implementation in the field. The project work plans will specify all necessary details to complete the aquifer testing at a particular site.

Aquifer testing information and specifications in the project work plans will describe, at a minimum, the following:

- Objectives of the aquifer testing
- Aquifer parameters to be evaluated
- Type(s) of aquifer tests to be conducted
- Exact wells to be used for aquifer testing
- Equipment types and requirements
- Type, duration, and frequency of measurements to be made
- Additional procedures or requirements beyond those covered in this SOP

Decontaminate all equipment that could come into contact with the well or groundwater and calibrate all instruments before obtaining field data according to SWE-FSOP-801 (Equipment Decontamination) and SWE-FSOP-107 (Equipment Calibrations), respectively. Equipment in contact with groundwater at one location must be decontaminated before reusing at another location.

> [PFAS Project]: Reusable non-dedicated equipment will be rinsed with certified PFAS-free water before and after use. If another water source is used, collect a water sample and run laboratory tests for PFAS before using that source.

The following requirements, responsibilities, and procedures described in the next section must be incorporated into the aquifer testing conducted at each site.

4.2 Slug Test Method

A slug test is an aquifer test in which the water level in a well is changed by removing, adding, or displacing a known volume of water. The water level response is monitored in the slugged well. The water level response is generally proportional to aquifer transmissivity and hydraulic conductivity.

A known volume of water can be removed relatively rapidly from the well with a submersible pump or bailer. Potable water can be added rapidly to a well by directly dumping from barrels or holding tanks. However, the most common method in environmental projects involves inserting and removing a solid slugging rod (or pig), which instantaneously displaces the water inside the well.

Water levels may be measured with an electric tape during testing if the wells recharge slowly. However, pressure transducers (with associated data loggers) are more commonly used to measure water levels as they can record a large number of measurements on a more rapid basis. Many brands of transducer/data logger packages can pre-program the measurement rate, obtaining frequent measurements during the initial portions of the test and less frequent measurements near the end as the water level slowly stabilizes.

The below procedures are used with a slugging rod and pressure transducer/data logger during slug testing. These procedures also cover slug insertion and slug withdrawal portions of slug testing. In certain instances, only the slug withdrawal test data are used for analysis. However, it is advisable to conduct the slug insertion test even if only using the withdrawal test data to evaluate aquifer parameters. The slug insertion test can provide information to make necessary adjustments to the withdrawal test in the field.

The procedures described below are readily adaptable for the other slug testing methods. The project work plans will outline specific slug testing methods and procedures.

- Any newly installed wells to be slug-tested must be developed before beginning slug testing activities.
- Inspect the equipment to ensure that it is in good working order. Aquifer slug test equipment will vary widely depending on the formation, other site conditions, the diameter and depth of the wells, and the number of wells to be tested. The project work plans will outline the type of equipment to be used.
- All measuring and testing equipment (M&TE) used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards that are traceable to the National Institute of Standards and Technology (NIST). Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment according to SWE-FSOP-801. Suppose the contaminant histories of the wells to be tested are known or anticipated. In that case, the slug tests should be performed, starting with the least contaminated well and ending with the most contaminated. It is recommended to replace the braided rope or line that has been submerged during slug testing of one well before moving on to another. These practices will reduce the potential for cross-contamination between wells.
- Visually inspect and access the wellhead per SWE-FSOP-602.

- Obtain a water level depth measurement and sound the bottom of the well according to the procedures outlined in SWE-FSOP-602. Compare the measured total depth to the bottom of the well with the well construction diagram to determine if sediment is at the bottom of the well. It is important not to set the pressure transducer in the sediment.
- Calculate the height of the water column in the well as follows:

  (h_1 - h_2) = height of water column in well

  Where:

  h_1 = total depth of well from the top of casing (in feet)
  h_2 = depth to water from the top of casing (in feet)
- The water column height should be sufficient to immerse the slugging rod and allow concurrent use of a pressure transducer or other measuring equipment during the testing.
- Connect the pressure transducer to the data logger. Install the pressure transducer in the water column to a depth that will not interfere with the insertion or withdrawal of the slugging rod during testing but also not exceed the maximum head limitation of the transducer.
- Obtain a barometric pressure measurement if testing (water level recovery) is expected to take longer than 30 minutes. Station barometric pressure may be recorded from onsite equipment or obtained from a local weather station.
- Turn on the pressure transducer/data logger and set the frequency that the recorder stores data measured from the transducer and displays a reading) for pre-test monitoring to that specified by the project work plans.
- Measure the water level with an electric tape (or equivalent) and record along with the measurement time. Commence pre-test monitoring with the pressure transducer/data logger. The time the pre-test measurements are made will be specified in the project work plans. The total time should be roughly equal to or greater than twice the time expected to run the slug test.
- Once the pre-test monitoring period is ended, remeasure the water level using the electric tape and record along with the measurement time.
- Change the recording frequency on the data logger for the slug-in test as specified in the project work plans. Lower the slugging rod to just above the static water level. Record the test's initiation time on the appropriate form, as outlined in the project work plans.
- The slugging rod should be completely submerged. However, it is best to lower the rod only enough to make sure it is submerged and not more. This will reduce the chance of pinching the transducer cables, dragging the transducer, or sticking the rod.
- Continue to monitor water level decline with the pressure transducer/data logger, taking periodic water level measurements with the electric tape. Data logger and tape readings should be conducted by the schedule outlined in the project work plans.
- The slug-in test may be terminated once the water level has declined to within 90 percent of the pre-test static or as specified in the project work plans. Once the slug-in test is terminated, take a physical water level measurement with the electric tape. Record the measurement and time on the appropriate form. Continue to the slug withdrawal ("slug-out") test.
- The slug withdrawal test should not be initiated until the water level has recovered to within 90 percent of static or as specified in the project work plans.

- Remeasure the water level using the electric tape and record the time.
- Change the recording frequency on the data logger to the appropriate frequency of data recording for the slug withdrawal test. The recording frequency will be specified in the project work plans but may be modified based upon a review of the slug-in test data. Concurrently with starting the data logger, immediately raise the slugging rod as quickly as possible such that the rod is entirely out of the water column and above the static water level. Record the test initiation time on the appropriate form as outlined in the project work plans.
- Continue to monitor water level rise with the pressure transducer/data logger, taking periodic water level measurements with the electric tape. Data logger and tape readings should be conducted by the schedule outlined in the project work plans and based upon a review of the slug-in test data.
- The slug-out test may be terminated once the water level has risen to within 90 percent of the pre-test static or as specified in the project work plans. Once the slug-out test is terminated, take a physical water level measurement with the electric tape. Record the measurement and time on the appropriate form.
- The data should be reviewed in the field to help ensure the validity of the test. Complete all documentation on the appropriate form as outlined in the project work plans.
- The slug-in and slug-out tests may be repeated as necessary and as required by the project work plans.
- Once all tests are satisfactorily completed for the well, all downhole equipment may be removed and the wellhead secured.

4.3 Specific Capacity Testing

Specific capacity tests are short-term single-well aquifer tests that are useful in highly transmissive units which preclude slug testing. The method measures the stabilized drawdown in the well while pumping at a uniform rate. The tests may be conducted in monitoring, extraction, and injection wells. Specific capacity tests can be conducted at the end of well development using the pump utilized for development. While less accurate than long-term multiple-well pumping tests, specific capacity tests provide fast and easy-to-interpret data for estimating hydraulic conductivity and transmissivity near the tested wells.

- Newly installed wells to be specific capacity tested must be developed before beginning testing activities.
- Inspect the equipment to ensure that it is in good working order. Specific capacity test equipment may vary widely depending on the formation and site conditions, the diameter and depth of the wells, and the number of wells to be tested. The project work plans will outline the type of equipment to be used. This step may be skipped if the specific capacity testing is to be conducted immediately after development using the development equipment.
- All M&TE used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards that are traceable to the NIST. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment according to SWE-FSOP-801. Suppose specific capacity testing is to be conducted immediately after development using the same equipment, and the

equipment has not been removed from the well site. In that case, the equipment may not have to be decontaminated for the testing.

- If the contaminant histories are known or suspected for the wells to be tested, the tests may then be performed, starting with the least contaminated and ending with the most contaminated. This will reduce the potential for cross-contamination between wells.
- Visually inspect and access the well per SWE-FSOP-602.
- Obtain a water level depth measurement and sound the bottom of the well according to the procedures outlined in SWE-FSOP-602. Compare the measured total depth to the bottom of the well to the well construction diagram to determine if sediment is at the bottom of the well.
- Install the mechanical pump in the well using the manufacturer's instructions. Place the pump in the well so that the pump intake is near the bottom of the well screen or the location of water entry into the well. Lower the pump inside the pumping well to a depth below the bottom of the anticipated drawdown. Note the height of the water column from the static water level to the pump motor housing and intake. Record all information on the appropriate form specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.
- Immediately before turning on the pump, physically measure the water level in the well. Start the mechanical pump and adjust the valve or flow regulator to maintain a constant discharge specified by the project work plan or as determined from the well development records. The discharge rate should be sufficient to maintain a stabilized sustainable drawdown of at least 0.1 feet. Record the time of the start of the specific capacity test on forms specified in the project work plans.
- Once pumping starts, physically measure the water level decline with the electric well tape (or equivalent) as directed at time intervals specified by the project work plans. Observe and record the wellhead flow meter readings at intervals specified by the project work plan. Record these measurements and the time on the appropriate form.
- Once the drawdown stabilizes (i.e., the water level under pumping is relatively stable), continue pumping for a sufficient time as specified in the project work plans. The project work plans will specify the criterion for stabilization of water levels and drawdown. During this time period, continue to physically measure and record the water levels at intervals stated in the project work plans.
- Once the specified period has elapsed, take a physical water level measurement with the electric tape and shut the pump down. Record the measurement and time on the appropriate form.
- The data should be reviewed in the field to ensure that valid data have been collected. This includes verification that discharge was maintained at a constant rate and the drawdown stabilized at the minimum required magnitude. Complete all documentation on the appropriate form as outlined in the project work plans.
- The specific capacity test may be repeated as necessary and as required by the project work plans.
- Once all tests are satisfactorily completed for the well, all downhole equipment may be removed and the wellhead secured.

4.4 Aquifer Pumping Test Methods

The pumping test methods covered in this section include step-drawdown tests and constant rate pumping tests. A step-drawdown test is conducted for the pumping well and is recommended before initiating any constant rate pumping test. The data provided by the step-drawdown test is used to evaluate well performance and determine the optimum discharge for the subsequent constant rate test.

The step-drawdown test entails conducting three or more steps of increased discharge while monitoring water level drawdown. This effectively produces successive stepped drawdown curves. Aquifer testing may be discontinued at a well after the step-drawdown pumping test if 1) only a single-well pumping test is planned, and 2) the step-drawdown test provides all the necessary data of a single-well pumping test.

The constant rate pumping test method involves pumping water from a well at a constant rate and monitoring the water level drawdown in response to the pumping. Water level recovery may also be monitored after the pumping is discontinued.

Water level monitoring may be limited to the pumping well (single-well pumping test) or include one or more nearby observation wells (multiple-well pumping test). The single-well pumping test utilizes a single-well (the pumped well) and a mechanical pump to remove water at a constant rate from the water-bearing unit. The same well is used to measure water level drawdown and recovery in the formation.

The multiple-well test utilizes one or more observation wells at selected distances and locations relative to the pumping well. Water levels are monitored in the pumping and observation wells throughout the test duration.

The remaining discussion provides the requirements and procedures for step-drawdown tests and single- and multiple-well constant rate pumping tests. These represent minimum requirements as site- and project-specific information and criteria must be incorporated in planning and conducting pumping tests. The project work plans will provide additional requirements and procedures for the specific pumping tests.

The procedures below describe the use of pressure transducers and data loggers to monitor water levels during the pumping testing. However, other water level measurement techniques may be substituted, and the procedures may be modified as appropriate in the project work plans.

4.4.1 Step-Drawdown Testing

Step-drawdown testing should be conducted before other pumping tests are performed. All newly installed wells should be developed before conducting step-drawdown tests.

- Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the step-drawdown testing will vary widely based on site-specific conditions. The project work plans will outline the type of equipment to be used.
- M&TE used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards that are traceable to the NIST. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be utilized without verification of calibration certification.
- Decontaminate all downhole equipment according to SWE-FSOP-801.

- Visually inspect and access the well per SWE-FSOP-602.
- Obtain a depth to water level measurement and sound the bottom of the well with the electric tape according to the procedures outlined in SWE-FSOP-602. Compare the measured total depth to the bottom of the well to the well construction diagram to determine if sediment is at the bottom of the well.
- Install the mechanical pump in the well per the manufacturer's instructions. The position of the pump intake inside the well should be based on well construction and site-specific factors stipulated in the project work plans. The criteria for placement of the pump in the well should also be contained in the project work plans. Lower the pump inside the pumping well to a depth below the bottom of the anticipated drawdown. Note the height of the water column from the static water level to the pump intake. Record all information on the appropriate form specified by the project work plans. During testing, the drawdown should not be so great as to cause the pump to cavitate.
- Connect the pressure transducer to the data logger. Lower the pressure transducer inside the pumping well to a depth below the bottom of the anticipated drawdown. The transducer should be installed at a level that: 1) eliminates effects from the pump intake, 2) is below the anticipated water level during the maximum drawdown, and 3) does not exceed the maximum transducer head limitation. In addition, the transducer must be secured inside the pumping well so that the transducer will not be affected by turbulence from the pump. Record the depth of the transducer.
- Turn on the pressure transducer/data logger, and set the recording frequency for pre-test monitoring to that specified by the project work plans. (Data loggers should be kept secure to prevent tampering.)
- Physically measure the water level with the electric tape and record along with the time. Begin pre-test monitoring with the pressure transducer/data logger. The total time the pre-test measurements are made will be provided in the project work plans. Generally, water levels are recorded for a period before the step-drawdown test that is at least twice as long as expected for the step-drawdown test and the recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.
- Once the pre-test monitoring period is ended, remeasure the water level using the electric tape and record the time.
- Change the recording frequency on the data logger to the appropriate frequency of step-drawdown data entry as required by the project work plans. Begin recording water level measurements with a pressure transducer/data logger as needed for the project work plans for the initial pumping phase of the step-drawdown test. Start the mechanical pump and adjust the valve or flow regulator to maintain the constant rate of discharge specified by the project-specific work plan. This rate will be the first step in the step-drawdown test. Record the time of the start of the step-drawdown test as specified in the project work plans.
- Continue to monitor water level decline during the first step with the pressure transducer/data logger, taking periodic water level measurements with the electric tape. Data logger and tape readings should be conducted by the schedule outlined in the project work plans. As the first step continues, review the water level data and, if necessary, adjust the recording frequency of the data logger. Observe and record the wellhead flow meter readings as the project work plans require.

- Continue pumping and recording water levels and flow meter readings in the first step as long as required by the project work plans.
- Once the first step is ended, measure the water level with the electric tape and record depth and time. Adjust the data logger as necessary (based upon a review of data from the first step) or specified in the project work plans for beginning the second step of the test.
- Without turning the mechanical pump off, initiate the second step of the test by changing the pumping rate with the valve or flow regulator to the rate specified by the project work plans.
- Monitor the water levels and flow meter readings.
- Repeat the cycles of changing the pumping rate and recording water depth as often as required (for each step of the step-drawdown test) by the project work plans.
- Once the last step is completed, re-set the data logger for the recovery period measurement duration and frequency as specified in the project work plans. Obtain a water level measurement with the electric well tape and record the measurement and time. Shut down the mechanical pump. Record the time that the pump was shut down on the appropriate form.
- Continue to measure and record the water level recovery with the pressure transducer/data logger as long as the project work plans require it or until the water level has recovered to 90 percent of the level expected from the pre-test trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period ends, take a physical water level measurement at the end of the test. Record the measurement and time on the appropriate form.
- The data should be reviewed in the field to help ensure the validity of the test. The field data review may also help determine the discharge rate used during the subsequent single or multiple-well-pumping testing. Complete all documentation on the appropriate form as outlined in the project work plans.
- Once the step-drawdown test is completed for the well, the equipment may be left in the well for subsequent single or multiple-well pumping testing. If the subsequent testing is not conducted, all downhole equipment may be removed and the wellhead secured.

4.4.2 Single and Multiple-Well Constant Rate Pumping Testing

The constant rate pumping test is the most commonly used method for obtaining estimates of aquifer properties. The procedures in this section are written as if a multiple-well pumping test is being conducted. However, these procedures are directly applicable to single-well testing. The only difference is that testing and measuring equipment is installed only in the pumping well, and water level measurements are collected from this well.

- Inspect the equipment to be used to ensure that it is in good working order. Equipment used for the pumping testing will vary widely based on site-specific conditions. The project work plans will outline the type of equipment to be used.
- M&TE used for field activities will be calibrated by the equipment manufacturer or an approved calibration laboratory using standards that are traceable to the NIST. Certificates of calibration for M&TE will be obtained from the M&TE supplier and kept in the project files. No M&TE will be used without verification of calibration certification.

- Decontaminate all downhole equipment according to SWE-FSOP-801. Equipment maintained inside the pumping well from the step-drawdown test and used directly for the subsequent pumping test does not need to be re-decontaminated.
- Visually inspect and access the wells used during the pumping test per SWE-FSOP-602.
- Obtain a depth to water level measurement and sound the bottom of each well to be used with the electric tape according to the procedures outlined in SWE-FSOP-602. Compare the measured total depths to the bottom of the wells to their respective construction diagrams to determine if sediment is at the bottom of the wells.
- If necessary, install the mechanical pump in the pumping well as described in Section 3.4.1.
- If a multiple-well test is conducted, connect the pressure transducers to their respective data loggers. Install the transducers inside the observation wells at this time. The transducers should be installed at a position inside each well that is below the anticipated water level during maximum drawdown and does not exceed the maximum head limitation. Set up another pressure transducer in an outlying well (outside the suspected influence of the pumping well) to record station barometric effects, if required. If not installed from the step-drawdown test, set the pressure transducer inside the pumping well as described in Section 3.4.1. Record the depth(s) of the transducer(s).
- Protect transducer cables that run across traffic areas. Data loggers should also be placed in a secure location to prevent tampering.
- Turn on the pressure transducers and data loggers, and set the recording frequencies for pre-test monitoring to that specified by the project work plans. Before initiating pre-test monitoring for the pumping test, it is also important to ensure that water levels from any previous step-drawdown testing have entirely recovered.
- Physically measure the water levels in the pumping and observation wells with the electric tape and record the time. Separate data sheets should be used for each well.
- Commence pre-test monitoring with the pressure transducers and data loggers. The total time the pre-test measurements are made will be provided in the project work plans. Generally, water levels are recorded for a period before the pumping test that is at least as long as expected for the pumping and recovery period. Record the information, including times of measurements, on the appropriate form as specified by the project work plans.
- Once the pre-test monitoring period is ended, remeasure the water levels in the wells using the electric tape and record along with the time.
- Change the recording frequencies in the data loggers for the pumping test as required by the project work plans. Just before starting the pump, begin recording the pressure transducer measurements.
- Start the mechanical pump and adjust the valve or flow regulator to maintain a constant rate of discharge as determined from the step-drawdown test and specified by the project work plans. Record the pump start time on the appropriate form.
- Continue to monitor water levels during pumping with the pressure transducers and data loggers, taking periodic water level measurements in each of the wells with the electric tape. Data logger and tape readings should be conducted by the schedule outlined in the project work plans. However, the water level data should be evaluated during the test and, if necessary, adjust the recording frequencies of the data loggers.
- Observe and record the wellhead flow meter readings as the project work plans require.

- The project geologist or designee will determine when the mechanical pump should be shut down as specified in the project work plans and based on a review of the field-generated drawdown versus time plots from the pumping and observation wells.
- Once the pumping phase is completed, re-set the data loggers for the recovery period, recording duration, and frequencies as specified in the project work plans. Obtain a water level measurement in each of the wells with the electric well tape and record the measurements and times. Shut down the mechanical pump. Record the time that the pump was shut down on the appropriate form.
- Continue to record the water level recovery in the wells with the pressure transducers and data loggers as long as is required by the project work plans or until the water levels have recovered to within 90 percent of the level expected from the pre-test trends. Also, continue to take physical water level measurements periodically during recovery. Once the recovery period is ended, take a physical water level measurement in each well at the end of the test. Enter the measurements and times on the appropriate form.
- The project work plans may require additional depth to water measurements to be physically taken following complete well recovery to monitor post-test trends in water level. The project work plans will specify the frequency of measurements and the time that the measurements must be taken.
- The data should be reviewed in the field to help ensure the validity of the test. Complete all documentation on the appropriate form as outlined in the project work plans.
- Once the wells' pumping test is satisfactorily completed, all downhole equipment may be removed and the wellheads secured.

4.5 Document Control

Aquifer testing field forms should be completed in their entirety. If an entry is not applicable, indicate “n/a” (not applicable) or line-out.

After a task or project, all field documentation, including the field logbook, field datasheets, and electronic data, shall be scanned and placed on the server in the appropriate folder. All original documents shall be submitted to the PL and kept in the project file. See SWE-FSOP-001 (Field Documentation).

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0 “Procedures”) and legibility. Errors and omissions should be explained, and revisions to an entry should be signed and dated by the FTL.

7.0 References

None cited.

Groundwater Well Installation

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Approvals

Christopher Ohland
SWE Quality Assurance Manager

October 10, 2022
Date

Bruce Wilcer
SWE Field Quality Control Manager

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Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures

Table of Contents

Introduction

1.1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to provide field staff with the proper techniques and documentation requirements to install groundwater monitoring, extraction, and temporary wells (hereafter referred to as “groundwater wells”)

1.2 Scope

The scope of this SOP applies to field staff conducting well installation oversight. The SOP includes guidance for the performance, management, and completion of installation activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control. Project-specific accident prevention plans (APP) and Site Safety and Health Plans address potential hazards related to well installation.

Per- and polyfluoroalkyl substances (PFAS) friendly procedures are also provided in this SOP. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Projects].

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for field completion drilling activities, including borehole logging and well construction according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the drilling subcontractor, well design, well installation activities, and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness, and accuracy of field documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Air Rotary Casing Hammer Drilling. A drilling method using a nonrotating drive casing that is advanced simultaneously with a slightly smaller diameter rotary bit attached to a string of drill pipe. Air is forced down through the center drill pipe to the bit, and the upward return stream through the space between the drive casing and the drill pipe removes cuttings from the bottom of the borehole.

Annular Space. The space between any of the following:

- Concentric drill pipes
- An inner drill pipe and outer drive casing
- Drill pipe or drive casing and the borehole wall
- Well screen or casing and the borehole wall

Borehole. Any hole drilled into the subsurface to identify lithology, collect soil samples, and install groundwater wells.

Cuttings. Pieces of soil, sediment, or rock-cut by a bit in drilling borings.

Extraction Well. A well used primarily to remove contaminated groundwater.

Filter Pack. Granular filter material (sand, gravel, etc.) placed in the annular space between the well screen and the borehole to increase the effective diameter of the well and prevent fine-grained material from entering the well.

Grout. For this SOP, the term "grout" consists of a neat cement grout generally containing three to five percent bentonite powder to water by weight. The grout is emplaced as a slurry. When correctly set and cured, it can restrict the movement of water.

Hollow Stem Auger Drilling. A drilling method using augers with open centers. The augers are advanced with a screwing or rotating motion into the ground. Cuttings are brought to the surface by the rotating action of the augers, thereby clearing the borehole.

Monitoring Well. A well that provides the collection of representative groundwater samples, the detection and collection of representative light and dense non-aqueous phase organic liquids, and the measurement of fluid levels.

Mud Rotary Drilling. For this SOP, the term "mud rotary drilling" refers to direct circulation (as opposed to reverse circulation) mud rotary drilling. Mud rotary drilling uses a rotating drill bit, and drilling mud is pumped through the inside of the drill pipe and the bit. The mud flows upward in the annular space between the borehole and the drill pipe, carrying the cuttings in suspension to the surface.

Sonic Drilling. A drilling method using high-frequency, resonant energy generated inside the sonic head to advance a core barrel or casing into subsurface formations. Sonic drilling is most often used when drilling (whether through particular ground materials or to a particular depth) is difficult, and the integrity of the core sample is extremely important.

Tremie. A tubular device or pipe used to place grout, bentonite, or filter pack in the annular space.

Well Screen. A perforated, wire-wound, continuous wrap, or slotted casing segment used in a well to maximize the entry of water from the producing zone and to minimize the entrance of sand and fine particulates.

2.0 Relevant Documents

This SOP focuses on the oversight and documentation of well installation activities and should be used in conjunction with state, county, and local well standards and other applicable SOPs, including the following:

Standard Operating Procedures

- SWE-FSOP-001 Field Documentation
- SWE-FSOP-300 Series (various drilling methods)
- SWE-FSOP-801 Equipment Decontamination
- SWE-FSOP-802 Investigation Derived Waste Management

Field Forms

- SWE-FFRM-401, Well Construction
- SWE-FFRM-004, Daily PFAS Sampling Checklist [PFAS Projects]

3.0 Equipment and Materials List

The list below identifies equipment expected to be used by staff while supervising well-installation activities.

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation

    [PFAS Project]: Field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Waterproof, indelible pens/markers in black or blue ink

    [PFAS Project]: Use ball-point pens. Do not use markers, felt pens, or pens with water resistant ink.

- Digital camera/video, cell phone, or other devices capable of digital imagery
- Appropriate PPE

The following materials are usually required for monitoring well installation. Review project-specific work plans for specific or unique materials or installation procedures.

- Steel protective locking cover or flush-mount well box and locking cap

- Flush-threaded riser pipe/"blank casing, " typically Schedule 40 or Schedule 80 polyvinyl chloride (PVC), typically sized at two-inch or four-inch diameter for permanent monitoring wells and work-plan-specified diameters for temporary wells, extraction wells, etc.
- Flush-threaded well screen, typically matching diameter and wall thickness of the riser pipe/"blank casing," with a slot size determined in advance based on site conditions and project objectives
- Measuring tape
- Plastic sheeting to protect decontaminated well materials

  [PFAS Project]: Clean, dry well materials should be stored within a protective medium (e.g., HDPE bag) or staged in a clean area for future use.

- Threaded or slip end cap
- Centralizer(s), as needed
- Silica sand (sized based on the formation material)
- Bentonite pellets or chips (for well seal or borehole fill according to project requirements)
- Pure bentonite powder and cement (for grouting wells; confirm the type of each and mixture specifications)
- Tremie pipe

4.0 Procedures

Procedures are provided for:

- Pre-Fieldwork tasks (Section 4.1)
- Field Preparation (Section 4.2)
- Mobilization and Set-Up (Section 4.3)
- Well Installation (Section 4.4)
- Temporary Monitoring Wells (Section 4.5)
- Demobilization/Site Restoration (Section 4.6)

4.1 Pre-Fieldwork Tasks

It is essential to be thoroughly familiar and compliant with state, county, or local well installation standards, codes, etc. They may contain requirements that must be used in conjunction with procedures presented in this SOP.

Site-specific factors must be considered in the selection of well installation and completion materials, specification of well designs, and well-drilling methods. The well design and other specifications are incorporated into project work plans or as the FTL/PL directs.

4.1.1 Clearances

Before starting any sonic boring, confirm that drilling locations have been appropriately cleared of potential overhead, surface, and subsurface hazards per the project work plans. This should include a utility locating subcontractor to identify subsurface infrastructure and anomalies. The clearance process also includes completing public utility locating service calls (e.g., Dig Alert, USA North 811, etc.) and completing any coordination and permitting procedures with the onsite Department/Directorate of Public Works personnel required by the project contract.

- Review available forms and diagrams that document the selected location of the drilling location relative to underground/overhead utility lines, surface structures, or buried objects.
- Copies of the site clearance documents should be kept onsite.

4.1.2 Health and Safety

- Hold Tailgate Safety Meetings in the manner and frequency stated in the health and safety plan.
- All personnel at the site should have appropriate training and qualifications as per the health and safety plan.
- All personnel within the exclusion zone should pay close attention to rig operations during drilling. The rotating or swinging drilling components can snag or catch loose clothing or strike personnel and cause severe injury or death.
- Hearing protection is especially critical when sonic drilling, as the rig can generate high-frequency noise and considerable noise when drilling through gravel and cobbles.
- Establishing clear communication signals with the drilling crew is mandatory since verbal signals may not be heard during the drilling process. The entire crew should be made aware to inform the driller of any unforeseen hazard—or when anyone is approaching the exclusion zone.

4.1.3 Site Conditions and Drilling Logistics

Prepare the site per the project work plans. Before mobilizing, determine the logistics of drilling, logging, sampling, cuttings/fluid containment, and well construction. The FTL or the Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards (i.e., slip/trip/fall, overhead power lines) and determine how drilling operations may impact the environment (i.e., dust, debris, noise). As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.

- Drill site space requirements commonly include an area for the rig and swing-out clearances, access for a pipe truck, and forklift carrying pipe or debris bins.
- The FTL or the Field Geologist should inform the driller of the appropriate equipment (e.g., cookie-cutter, etc.) to penetrate the surface cover (e.g., asphalt, concrete, cement, etc.).
- Lubricating compounds used on drill pipe and drive casing threads must be approved in advance and must not contain compounds incompatible with project objectives, laboratory analyses, or water quality guidelines.
- Drive casings of various lengths should be provided by the subcontractor to facilitate emplacement of the sand pack, bentonite seal, and grout during well construction. One 3-foot, two 5-foot, and two 10-foot lengths and enough standard-length drive casing joints are recommended.
- A hydraulic casing extractor must be used to remove the drive casing from the borehole. Do not extract the casing by "hammering up" with the casing hammer. The hydraulic casing extractor should have sufficient pulling capacity and clamping mechanisms to extract the casing safely and smoothly with the appropriate lifting force.

4.1.4 Rig Decontamination and Preparation

- All drilling and sampling equipment should be decontaminated before drilling per SWE-FSOP-801. “Equipment Decontamination”
- The drilling equipment shall be inspected for proper maintenance and appropriate decontamination before each time the rig is mobilized to a site
- All clutches, brakes, and drive heads should be properly working
- All cables and hydraulic hoses should be in good condition
- Any observed leakage of fluids from the rig should be immediately repaired and decontaminated again before it is allowed to mobilize

4.1.5 Calibrations

Before mobilization, calibrate the safety-related sampling and monitoring equipment.

4.1.6 Personal Protective Equipment (PPE)

Provide workers with the appropriate PPE as specified by the project work plans.

4.2 Mobilization and Set-Up

The standard procedure for installing groundwater wells is described below, and the project work plans may include additional specifications.

4.2.1 Site Preparation

The logistics of drilling, cuttings/fluid containment, and well construction should be determined before mobilizing. The site should be prepared as per the project work plans.

- As per the site health and safety plan, appropriate barriers and markers should be in place before drilling
- Plastic sheeting (e.g., Visqueen™) may be required beneath the rig
- Appropriate cuttings and other IDW containment should be set onsite before the commencement of drilling
- If drilling is conducted in the saturated zone, provisions should be made to ensure adequate containment of formation water produced during drilling operations
- Clear the work site of all brush and minor obstructions and then mobilize the rig to the monitoring well location

4.2.2 Discussion of Site Conditions

Before drilling operations begin, the following must be completed:

- The FTL or Field Geologist should assess the drilling site with the driller. This assessment should identify potential hazards and determine how drilling operations may impact the environment.
- As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location changed or shifted.
- If a shallow subsurface hazard (i.e., unidentifiable utility or trapped vapors) may exist, the driller should be informed of the potential hazard before breaking ground. Drilling should then commence slowly to allow continuous visual inspection and monitoring and, if necessary, stop for probing.

4.2.3 Mobilization

Once the site is prepared, the rig is mobilized and located over the borehole.

- The drill rig is mobilized to the site and located over the borehole location
- The drill rig is leveled with a set of hydraulic pads attached to the front and rear of the drill rig
- The driller should always raise the mast slowly and carefully to prevent tipping or damaging the rig and avoid obstructions or hazards

4.3 Well Installation Procedures

4.3.1 Drilling

The following procedures assume that the drilling of the borehole occurred per the project work plan and appropriate SOPs (see SWE-FSOP-300 Series [various drilling methods]).

During fieldwork, the Field Geologist will generally:

- Observe and monitor rig operations
- Conduct all health and safety monitoring and sampling, and supervise health and safety compliance

4.3.2 Borehole Preparation

At total depth, remove soil cuttings through circulation or rapidly spin the augers before constructing the well. Review logs and notes with the driller for any zones or depths exhibiting drilling problems that may affect the well installation. Condition the hole or take other actions mutually agreed upon by the Field Team (FTL, PL, Field/Project geologist, driller) to aid in the well installation.

Remove the drill pipe and bit if using rotary techniques, or remove the center bit if using the hollow stem auger technique. Install the well construction materials inside the open borehole or through the drive casing or augers center.

Measure the total depth of the completed boring using a weighted sounding line. The borehole depth is checked to assure that formation material has not heaved to fill the borehole. If heaving has taken place, discuss cleaning, re-drilling, or installation options in the open section of the boring with the Field Team (FTL, PL, Field/Project geologist, or driller).

4.3.3 Grouting Overdrilled Boreholes

If the hole was over drilled to a depth greater than needed for well installation, backfill material such as grout, bentonite pellets, or bentonite chips (as specified in the project work plans) may be added to the bottom of the boring to raise the bottom of the hole to the desired depth.

- Before placing materials, confirm the borehole dimensions and calculate the estimated volume of material required, including allowances for hydration of dry materials.
- Closely monitor the progress of borehole backfilling by frequently tagging the level in the borehole and comparing against estimated fill quantities. This is especially important if irregularities in the borehole are suspected (e.g., voids, sloughing).

- Pump grout through a tremie pipe and fill the borehole from the bottom of the boring upward. During grouting, submerge the tremie pipe below the top of the grout column in the borehole to prevent free fall and bridging.
- Add gradually to prevent bridging if bentonite solids (chips/pellets) are used.
- Obtain approval of the final depth of the borehole in advance from the FTL or PL. Stop grout or bentonite addition when the general level has reached approximately one foot below the desired base of the well string (casing, screen, end plug or sump, etc.). Hydrate the bentonite plug for at least one hour before installing a filter pack.

4.3.4 Assembling and Installing Well Casing

Before installation, inspect the casing, screen, silt traps, end caps, centralizers, locking covers, and any other well construction materials to confirm that no damage has occurred during shipment and decontamination activities.

During the inspection, confirm that all well component materials, dimensions, and quantities are accurate before proceeding. This includes confirming that the slot size on well screens matches project specifications.

If centralizers (commonly stainless steel) are used, confirm placement throughout the well string with the FTL, PL, or Field/Project geologist as appropriate.

Assemble and carefully lower the well string through the open borehole, drive casing, or inside the augers until the well string is at the desired depth. Suspend the well string by the installation rig, so it does not rest on the bottom of the boring. If the well string was dropped, lowered abruptly, or for any other reason suspected of being damaged during placement, the string should be removed from the boring and inspected.

In certain instances, the well string may rise after being placed in the borehole due to heaving sands. If this occurs, the driller must not place any drilling equipment (drill pipe, hammers, etc.) to prevent the casing from rising.

The Field Geologist notes the amount of rise and consults with Project Geologist for an appropriate course of action.

Record the following information in the FLB/notepad or field form SWE-FFRM-401, “Well Construction.”

- Diameter of the well boring
- Total depth of well boring
- Length of blank casing
- Length of well screen
- Length of the well end cap or silt trap
- Depth to base of well string
- Depth to top and bottom of well screen
- Depths of centralizers, if used

4.3.5 Installing Filter Pack

Based on borehole and well casing dimensions, calculating volumes of filter pack, bentonite pellets/slurry, and grout required. If the project work plans require, determine the filter pack and well screen slot size for the monitoring or extraction well.

Place a layer of filter pack (one to two feet, unless otherwise specified in the project-specific work plans) at the bottom of the borehole.

- When constructing wells within a cased hole or through hollow stem augers, install the filter pack by pouring and allowing it to free-fall through the center of the drive casing/augers or tremie according to project work plans. Add filter pack slowly while withdrawing the drive casing/augers. Take care to minimize the height of the filter pack inside the auger/drive casing during pouring to avoid potentially "sand locking" the well casing and pulling it up with the auger/drive casing.
- Using drive casing or augers, pull the drive casing or augers slowly during filter pack installation in increments no greater than five feet.
- For the mud rotary drilling technique, tremie the filter pack into the annular space around the screen. If approved, clean, potable water may be used to assist with the filter pack tremie operation.

Monitor filter pack settlement by initially measuring the sand level (before beginning to withdraw the drive casing/augers). Repeatedly take depth soundings using a weighted tape to continually monitor the level of the sand in the auger/drive casing as it is removed. Monitor the top of the well casing to detect any movement due to settlement or from drive casing/auger removal. If the top of the well casing moves upwards at any time during the well installation process, the driller should not be allowed to set drilling equipment (downhole hammers, drill pipe, etc.) on the top of the casing to prevent further movement, which could cause the well casing to bend or break in the borehole.

Add filter pack until its height is approximately two feet above the top of the screen (unless otherwise specified in the project work plans), and conduct verification of its placement (by sounding). Then gently surge the filter pack using a surge block or swab to settle the packing material and reduce the possibility of bridging.

Resound the height of the filter pack and add more filter pack, placed as necessary. Once filter pack placement is complete, measure and record the depth to the top of the pack in the FLB/notpad or field form SWE-FFRM-401, "Well Construction."

4.3.6 Installing Seals

Install a three-foot thick (unless otherwise specified in the project work plans) bentonite seal on top of the filter pack. If pellets or chips are used, add them gradually to avoid bridging. Take repeated depth soundings using a weighted tape to ascertain the top of the bentonite seal. Allow the seal to hydrate for at least 30 minutes before proceeding with the grouting operation.

After hydration of the bentonite seal, pump grout through a tremie pipe and fill from the top of the bentonite seal upward.

- Unless otherwise specified, cement grouts should be mixed using approximately 6 to 7 gallons of water per 94-pound bag of Type I/II Portland cement to a density of approximately 15 pounds/gallon.
- If needed, add bentonite (5 to 10 percent) to the cement grout to strengthen the mix and delay the setting time.
- Specific mixtures and other types of cement and grout proposed should be evaluated on a case-by-case basis by the field geologist and communicated to the drillers.

During grout installation, maintain the bottom of the tremie pipe below the top of the grout to prevent free fall and bridging. When using drive casing or hollow stem auger techniques, raise the drive casing/augers in short increments during grout pouring, keeping the bottom of the drive casing/augers below the top of the grout. It is essential to calculate the approximate volume of grout required; note reduced/excessive volumes, which may indicate irregularities in the annulus or grout flow into a formation. Cease grouting when the grout level has risen to approximately one to two feet of the ground surface, depending on the surface completion type (flush-mount versus aboveground). Monitor grout levels to ensure that grout taken into the formation is replaced by additional grout. If settling occurs, additional topping off of the grout may be necessary.

4.3.7 Protective Casing

For aboveground completions, place the protective steel casing (e.g., lockable “stovepipe”) over the top of the well casing and insert it into the freshly grouted annulus. Before installation, place a 2-inch thick temporary spacer between the PVC well cap and the bottom of the protective casing cover to keep the protective casing from settling onto the well cap. Note: confirm the final clearance required between the top of the well casing and the cover; additional room may be needed for dedicated well equipment.

After the protective casing is set in the grout, a drainage hole may be drilled into the protective casing if required in project work plans. The drainage hole is positioned approximately two inches above ground surface. Paint the protective casing with rust-preventive colored paint. Make sure the well is protected from potential vapors from paint.

Label the wellhead to provide information such as well number, depth, and date of the installation based on project requirements.

Wait 24 hours after grouting before installing concrete pad and steel guard posts (bollards) for aboveground completions or street boxes or vaults for flush-mount completions.

Aboveground Completions

A concrete pad, usually 3-foot by 3-foot by 4-inch thick, is constructed at ground surface around the protective steel casing. The concrete is sloped away from the protective casing to promote surface drainage away from the well.

Where traffic conditions warrant extra protection, embed three to four steel guard posts (bollards) to a depth approximately 1.5 feet below ground surface with three to four feet of stickup depending on project requirements. Install the posts in concrete-filled post holes spaced equally around the well, commonly at 1.5 feet from the protective steel casing (check work plan for exact specifications). Where posts are removed for well access, embed mounting sleeves into the concrete.

Flush-Mount (or Subgrade) Completions

Before installing any street box or vault over a well, confirm all clearances between the well cap and inside vault lid and the final height of the vault top above ground surface. Where installations are in parking lots, roads, concrete slabs, etc., consider the final height of the surrounding surface.

Set and cement into position a street box or vault, usually one inch to a few inches above ground surface, depending on design requirements. Raise the top of the street box or vault slightly above grade, and the cement sloped to grade to promote surface drainage away from the well.

4.4 Temporary Monitoring Wells

4.4.1 Temporary Well Materials

Materials used in installing temporary monitoring wells are the same standard materials used in the installation of permanent monitoring wells.

Sand used for the filter pack (if any) should be as specified in the work plan. The well screen and casing should be stainless steel (for ruggedness and suitability for steam cleaning and solvent rinsing) or polyvinyl chloride. Appropriate Quality Assurance (QA) and Quality Control (QC) must be performed to ensure no introduction of contaminants.

4.4.2 Temporary Well Borehole Construction

Ensure that borehole construction for temporary wells is of sufficient diameter to accommodate the well casing and associated well construction materials.

For well installation in an open borehole using a drill rig, ensure the annular space is approximately 2 inches to allow the uniform deposition of well materials around the screen and riser and allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen or entirely removed before sampling.

When hand augers are used, the borehole is advanced to the desired depth (or to the point where borehole collapse occurs). When borehole collapse occurs, the auger bucket is typically left in the hole at the point of collapse while the temporary well is assembled above ground. When the well is completely assembled, a final auger bucket of material is quickly removed, and the well is immediately inserted into the borehole, pushing, as needed, to achieve maximum penetration into the saturated materials.

4.4.3 Temporary Monitoring Well Types

Temporary monitoring wells are constructed in various ways depending on project requirements and site conditions. A few acceptable examples are described below. Because temporary well purposes and construction are project-specific, detailed procedures for construction should be included in project work plans.

1. **No Filter Pack.** After the borehole is completed, the casing and screen are simply inserted. This is the least expensive and fastest well to install. **Note:** *This type of well is extremely sensitive to*

turbidity fluctuations because there is no filter pack. Take care not to disturb the casing during purging and sampling.

2. **Traditional Filter Pack**. The screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. **Note**: *Occasionally, it may be difficult to effectively place a filter pack around shallow open boreholes due to collapse. This method requires more sand than the "inner filter pack." As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity*.
3. **Well-in-a-Well**. The borehole is advanced to the desired depth. A 1-inch well screen and sufficient riser are inserted into a 2-inch well screen with sufficient riser and then centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, approximately 6 inches above the screen. The assembled well is then inserted into the borehole.

Temporary wells are commonly used for short periods (days/weeks) and should be decommissioned when no longer needed. See FSOP-603 Well Decommissioning for procedures.

4.5 Demobilization/Site Restoration

All debris generated by the drilling operation/well construction should be disposed of appropriately. The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans. All monitoring wells should finish their surface completions as per the project work plans. Any hazards remaining due to drilling activities should be identified, and appropriate barriers and markers should be put in place, as per the APP. All soil cuttings and fluids should be adequately contained, clearly labeled, and maintained to comply with the project work plans.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for well installation field documentation review will be performed by the FTL or PL to check that procedures and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

If a non-registered geologist performs the oversight, a registered Project Geologist is responsible for reviewing the fieldwork documentation for the accurate and complete representation of the drilling and approval of final logs/forms.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

The PL is responsible for the review and signoff of final approved documents stored in the project file.

7.0 References

None cited.

Groundwater Well Development

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Approvals

October 10, 2022

Christopher Ohland
SWE Quality Assurance Manager

Date

October 10, 2022

Bruce Wilcer
SWE Field Quality Control Manager

Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures

Table of Contents

Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques and documentation of for developing temporary and permanent groundwater monitoring and extraction wells (hereafter referred to as “groundwater wells”) after their installation and before their designated use. This method may also be used as part of rehabilitation or re-development of a well during its lifecycle.

The details within this SOP should be used in conjunction with project-specific work plans, Accident Prevention Plans (APP) and Site Safety and Health Plans.

1.2 Scope

The scope of this SOP applies to field staff performing or conducting oversight of groundwater well development. The SOP includes guidance for the performance, management, and completion of development activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control. Project-specific APP and Site Safety and Health Plans address potential hazards related to well development.

Per- and polyfluoroalkyl substances (PFAS) friendly procedures are also provided in this SOP. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Projects].

1.2.1 Resources and Requirements

In addition to project-specific procedures and requirements, it is essential to be thoroughly familiar and compliant with state, county, or local well installation (and development) standards, codes, etc. as they may contain requirements that must be used in conjunction with, or instead of procedures presented in this FSOP.

1.3 Responsibilities

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist. A Field Geologist is responsible for overseeing development activities according to project specifications. The Field Geologist is a registered geologist or a person performing work under the supervision of a registered geologist.

Project Geologist. The registered Project Geologist is responsible for oversight of the well development subcontractor and field documentation. When a Field Geologist performs the oversight, the Project Geologist is responsible for fieldwork variances/deficiencies, completeness and accuracy of field documentation, and approval of the well development completion.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current version of U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies and incidents and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Bailer. A bottom-filling cylindrical tube with an open top and check valve at the bottom used to remove water and sediment from a borehole or well.

Bailing. A well development technique uses a bailer raised and lowered in the well to create a strong inward and outward movement of water from the formation, break sand bridges, and remove water and fine-grained materials from the well.

Extraction Well. A well designed to extract fluids (such as water, gas, free product, or a combination) from the subsurface.

Field Documentation – The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Forms – Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB. Each data entry field should have an entry or indicate that data for that field is not available or not required.

> [PFAS Project]: Record of field events will be maintained on loose paper (PFAS-free) secured on Masonite or aluminum clipboards. Plastic clipboards, binders, or spiral hard cover notebooks are not acceptable. Field logbooks are permanently assigned to a specific project.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

> [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

Field Notepad – A unbound notepad or loose-leaf paper with consecutively numbered pages.

Investigation Derived Waste (IDW). Waste that is generated in the process of investigating or examining a contaminated site.

Monitoring Well. A well that provides the collection of representative groundwater samples, the detection and collection of representative light and dense nonaqueous phase organic liquids, and the measurement of fluid levels.

Mudwall. A layer of fine-grained soils formed around the boring annulus during drilling can impede the formation water's free flow into a well.

Piezometer. A tube placed in soil to depths below the water table extends to the soil surface and opens to the atmosphere. The bottom of the piezometer is perforated or slotted to allow groundwater water under positive hydrostatic pressure to enter the tube.

Surging. A well development technique in which a surge block is alternately raised and lowered within the well casing or screen to create a strong inward and outward movement of water through the well screen. Surging helps remove fine-grain material from the boring wall and the filter pack.

Turbidimeter. An instrument measuring the turbidity (the cloudiness or haziness of fluid caused by individual particles) of a liquid.

Well Casing. A durable pipe placed in a borehole to prevent the walls of the borehole from caving in, and to seal off surface drainage or undesirable water, gas, or other fluids, and prevent their entrance into the well.

Well development. The act of removing fine-grained sediment and drilling fluids from the sand pack and formation in the immediate vicinity of the well, thus increasing the porosity and permeability of the materials surrounding the intake portion of the well.

Well Screen. A perforated, wire-wound, continuous wrap, or slotted casing segment used in a well to maximize the entry of water from the producing zone and to minimize the entrance of sand and fine particulates.

2.0 Relevant Documents

Standard Operating Procedures

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-101, Water Quality Measurements
- SWE-FSOP-102, Groundwater and NAPL Measurements
- SWE-FSOP-801, Equipment Decontamination
- SWE-FSOP-802, IDW Management

Field Forms

- SWE-FFRM-004, Daily PFAS Sampling Checklist [PFAS Projects]
- SWE-FFRM-402, Well Development
- SWE-FFRM-501, Water Level/NAPL Measurements
- SWE-FFRM-801, Equipment Calibration

3.0 Equipment List

The list below identifies equipment expected to be used by staff while supervising well development activities.

- A bound, waterproof field logbook (e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation

  [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Waterproof, indelible pens/markers in black or blue ink

  [PFAS Project]: Ball-point pens: do not use markers, felt pens, or pens with water resistant ink

- Digital camera/video, cell phone, or other devices capable of digital imagery

For monitoring well development, the following materials are usually required. Review project-specific work plans for specific or unique materials or installation procedures:

- Surge block on a cable or line (commonly on a development rig)
- Submersible pump, peristaltic pump, and bailer (Note: bladder and gear pumps are not recommended because of pump damage from fine sediments)
- Groundwater purge container, tank, or drum of known volume for flow estimation
- Water quality monitoring instrument(s) (e.g., YSI Water Quality Meter) capable of measuring parameters such as dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, pH, turbidity, and temperature
- Clear glass jars (at least 2)

  [PFAS Project]: Two clear PFAS-free containers

- Water level indicator
- Measuring tape/sounder
- Decontamination equipment including soap (i.e., Liquinox™), de-ionized and tap water
- Plastic sheeting to protect decontaminated tools

  [PFAS Project]: Clean, dry development equipment should be stored within a protective medium (e.g., HDPE sheeting) or staged in a clean area for future use.

4.0 Procedures

This section contains procedures for developing groundwater wells. Additional guidance can be found in SWE-FSOPs listed in Section 2.0 and references in Section 7.0.

Procedures are provided for:

- Preparation Tasks (Section 4.1)
- Mobilization and Setup (Section 4.2)

- Development Procedures (Section 4.3)
- Documentation (Section 4.4)
- Demobilization/Site Restoration (Section 4.5)

4.1 Pre-Field Tasks

Preparation and coordination tasks for sonic drilling generally include the activities described below.

4.1.1 Clearances

Before starting well development, confirm that groundwater well locations have been appropriately cleared of potential overhead, surface, and subsurface hazards per the project work plans. Before raising the mast on any development rig, ensure appropriate clearances are maintained from nearby/overhead structures and power and communication lines.

4.1.2 Health and Safety

- Hold Tailgate Safety Meetings in the manner and frequency stated in the health and safety plan.
- All personnel at the site should have appropriate training and qualifications as per the health and safety plan.
- All personnel within the exclusion zone should pay close attention to rig operations during well developmnet. Rotating or swinging components can snag or catch loose clothing or strike personnel and cause severe injury or death.

4.1.3 Rig Decontamination and Preparation

Decontaminate all downhole equipment, sounders, bailers, pumps, and other materials used during well development. Procedures should follow SWE-FSOP-801 (Equipment Decontamination).

> [PFAS Project]: In general, all well development equipment will be washed with certified PFAS-free potable water and detergents such as Alconox, Liquinox or Citranox and should end with a triple rinsing with laboratory certified PFAS-free de-ionized water. If another source is used, a sample should be collected and tested for PFAS. If the concentrations are low enough to meet project Data Quality Objectives, the water is acceptable for use.
>
> Wherever possible, development equipment should also be rinsed immediately before use.

4.1.4 Calibrations

Before mobilization, calibrate the safety-related sampling and monitoring equipment, water quality meters, and other measuring devices according to the instrument manufacturer's specifications.

4.1.5 Personal Protective Equipment (PPE)

Provide workers with and don the appropriate PPE specified by the project work plans.

4.2 Mobilization and Setup

The standard procedure for well development is described below. Project work plans may have additional specifications.

4.2.1 Site Preparation

Before mobilizing, the logistics of well development, fluid containment, and site management should be determined. The site should be prepared as per the project work plans.

- Appropriate barriers and markers should be in place prior to well development, as per the site health and safety plan
- Plastic sheeting (e.g., Visqueen™) may be required beneath the rig
- Appropriate IDW containment should be set onsite prior to the commencement of well development

4.2.2 Discussion of Site Conditions

Before development operations begin, the following must be completed:

- The FTL or designee should assess the well site with the driller. This assessment should identify potential hazards and determine how operations may impact the environment
- As per the project work plans, potential hazards should be evaluated and corrected
- Potential hazards should be evaluated and corrected
- If hazard(s) (e.g., free product, vapors) may exist, the driller should be informed of the potential hazard(s) before starting work

4.2.3 Mobilization

Once the site is prepared, the rig is mobilized and located over the groundwater well.

- Level the rig with a set of hydraulic pads attached to the front and rear of the rig
- Raise the mast slowly and carefully to prevent tipping or damaging the rig and avoid obstructions or hazards
- Appropriate barriers and markers should be in place before drilling, as per the site health and safety plan

4.3 Development Procedures

Perform well development as soon as practical after well installation, but in compliance with applicable state or local requirements for seal curing times, which may range from a minimum of 48 to 72 hours following well installation.

> [PFAS Project]: The cap and all internal components of the well casing above the water table shall be rinsed with PFAS-free water to remove all traces of soil, sediment, and cuttings, before and/or during well development. Dedicated materials shall be used for well development.

Record details of development activities in the Well Development form (SWE-FFRM-402.00).

1. Measure and record the water level and total depth of the well using a water level indicator per SWE-FSOP-102 (Groundwater and NAPL Measurements). Note any accumulated sediment thickness, and record information in the FLB and on form SWE-FFRM-402.00 (Well Development).
2. Begin well development by removing any accumulated sediment from the bottom of the well using the bailer. Repeat this process until as much accumulated sediment as possible has been removed from the bottom of the well.

3. Begin surging the entire well screen using a surge block. A general rule for well development is to start slowly and gently, and gradually increase agitation as the well is developed. After a minimum of fifteen minutes, remove the surge block and immediately begin to bail the sediment-laden water. The length of time required at this stage will depend on various conditions such as water clarity, sediment levels, etc. Contain all development water for proper disposal, according to the site-specific work plan and SWE-FSOP-802 (Investigation Derived Waste Management).
4. Repeat surging and bailing for several cycles developing the well from the bottom of the screened interval upward by alternately using the surge block and the bailer. Record the surge interval and duration of surging and bailing.
5. During development, monitor the clarity of the water removed from the well. Measurements can be collected using a calibrated turbidity meter, with results recorded on the development log or FLB/notepad.

   [PFAS Project]: Fill a clear PFAS-free container with development water to observe turbidity if necessary.

6. Once it is determined that the well has been adequately developed using the bailer and surge block, use an appropriately sized pump to continue development, typically placed near the bottom of the screen interval. Wells with screen lengths greater than ten feet may be pumped from multiple depths during this process.
7. Pumping should begin at a rate to minimize drawdown. Monitor groundwater levels with a sounder and adjust accordingly. Ideally, the pump should be operated at the maximum discharge rate as long as groundwater levels remain above the pump intake. Collect water quality parameters to check for water quality stability, emphasizing turbidity until the well is determined to be fully developed. Generally, at least ten well volumes are removed or until turbidity reaches the desired level (DTSC, 2014). Typically, 5 NTUs is considered satisfactory. If turbidity stabilization cannot be achieved, contact the FTL for their recommendation.
8. If the well recovers naturally (i.e., drawdown can be controlled/eliminated during pumping), continue development with formation water only. However, if the well is purged dry at any point during development, the process to complete the well development should be determined by the FTL.
9. Variability in geologic, ambient water, and well construction characteristics create conditions where exact criteria for determining adequate completion of well development are not feasible. The purpose of the well, type of contaminant, and geologic conditions must be considered when deciding on the appropriate level of development. Therefore, determining what constitutes acceptable development is considered a professional judgment determined by the Project Geologist or PL.
10. Measure and record a final depth to water and total well depth after well development.
11. Manage development water generated during well development as IDW, in accordance with the designated work plan or site waste management plan, and SWE-FSOP-802 (Investigation Derived Waste Management).

4.4 Demobilization/Site Restoration

After well development is completed, the tools should be laid down, the mast lowered, and the rig moved off the location. The FTL or designee should supervise the demobilization/site restoration.

Any debris generated by the well development operation should be disposed of appropriately. The site should be cleaned, the ground washed as necessary, and the site conditions restored as per the project work plans. Any hazards remaining due to well developnment activities should be identified, and appropriate barriers and markers should be put in place, as per the APP. All fluids should be adequately contained, clearly labeled, and maintained to comply with the project work plans.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for drilling and field documentation review will be performed by the FTL or PL to check that procedures and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

If a non-registered geologist performs the oversight, a registered Project Geologist is responsible for reviewing the fieldwork documentation for the accurate and complete representation of the drilling and approval of final logs.

6.0 Documentation Review

The FTL is responsible for daily review of the activities performed at the site and fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

Department of Toxic Substances Control (DTSC), California Environmental Protection Agency, 2014. *Well Design and Construction for Monitoring Groundwater at Contaminated Sites*. June.

Environmental Protection Agency (EPA), Region 4, Science and Ecosystem Support Division, Athens, Georgia, 2018. *Design and Installation of Monitoring Wells*. SESDGUID-101-R2. January 16. https://www.epa.gov/quality/design-and-installation-monitoring-wells

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Test Pit Excavation/Trenching

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Christopher Ohland
SWE Quality Assurance Manager

February 15, 2023
Date

Bruce Wilcer
SWE Field Quality Control Manager

February 15, 2023
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Table of Contents

Introduction

1.1 Purpose

This Standard Operating Procedure (SOP) aims to provide field staff with the proper techniques and documentation requirements for constructing test pits (potholing) or trenches. Test pits and trenches may be excavated manually or using machinery to perform subsurface investigations of debris, utilities, shallow subsurface conditions such as geological and geotechnical features, or soil chemistry. In situ or grab soil sampling may be required to collect the appropriate samples specified in the work plan.

1.2 Scope

The scope of this SOP applies to field staff performing oversight of construction of test pits or trenches and guides the management, and completion of intrusive activities, including a description of staff responsibilities, relevant documentation, equipment, procedures, and quality control.

Test pits and trenches are open excavations used to determine the shallow subsurface conditions at a specified site. They are usually excavated within or along the boundaries of a known or suspected hazardous site for engineering, geological, or soil chemistry exploration and sampling purposes. However, there may be other reasons for excavation. Test pits and trenches are excavated manually with a shovel or using machinery such as a backhoe or trench excavator.

This SOP is limited to small-scale intrusive activities and does not discuss:

- Large-scale earthwork involving tracked excavators, loaders, graders, etc., requiring detailed plans and procedures (sloping, shoring, shielding, benching, etc.).
- Conditions where entry into a trench or test pit over 4 feet deep is required.
- Intrusive activities where Material Potentially Presenting an Explosive Hazard (MPPEH) is a concern, subject to special procedures to address known or potential surface and subsurface explosive hazards.

This procedure also defines the requirements and techniques for collecting media samples during and after the test pit and trench construction. Project-specific accident prevention plans (APP) and Site Safety and Health Plans (SSHP) should also be reviewed to address potential hazards related to these activities.

Per- and polyfluoroalkyl substances (PFAS) friendly procedures are also provided in this SOP. When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP, which is indicated by [PFAS Projects].

1.3 Responsibilities

Field Team Lead (FTL). The FTL reviews project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Field Geologist/Engineer. A Field Geologist/Engineer is responsible for completing excavation and logging activities according to project specifications. The Field Geologist/Engineer is a registered geologist/engineer or a person performing work under the supervision of a registered geologist/engineer.

Project Geologist/Engineer. The registered Project Geologist/Engineer is responsible for overseeing the excavation and logging activities and field documentation and ensuring that field personnel properly and safely construct test pits/trenches and collect samples per this and other relevant procedures. When a Field Geologist/Engineer performs the oversight, the Project Geologist/Engineer is responsible for fieldwork variances/deficiencies, completeness, and accuracy of field documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of the current U.S. Army Corps of Engineers EM-385-1-1 *Safety and Health Requirements*. The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the FTL of safety deficiencies, incidents, and actions to correct those. If the circumstance warrants, the FTL approves those actions and notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of the Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

Competent Person (CP). A designated person responsible for the supervision, implementation, and monitoring of the trench/test pit excavation, who through training, knowledge, and experience in excavation/trenching, can identify, evaluate, and address existing and potential hazards and who has the authority to take prompt corrective measures about such hazards.

1.4 Definitions

Type A Soil. Cohesive soil with an unconfined compressive strength of 1.5 tons per square foot or greater. Examples include clay, silty clay, sandy clay, clay loam, caliche, and hardpan. No soil should be classified as Type A if it is fissured, subject to vibration, or has been previously disturbed.

Type B Soil. Cohesive soil with an unconfined compressive strength between 0.5 and 1.5 tons per square foot, such as angular gravel, silt, silt loam, and sandy loam. Previously disturbed soil, fissured soil, or soil subject to vibration but meeting the strength requirements of Type A soil is considered Type B.

Type C Soil. Cohesive soil with an unconfined compressive strength equal to or less than 0.5 tons per square foot, such as gravel, sand, loamy sand, or submerged soil.

2.0 Relevant Documents

This SOP focuses on the oversight and documentation of test pits and trench excavation. It should be used in conjunction with other applicable SOPs and forms, including the following:

Standard Operating Procedures

- SWE-FSOP-001 Field Documentation
- SWE-FSOP-002, Field Sample Management
- SWE-FSOP-410, PFAS Sampling and Analysis – General Procedures
- SWE-FSOP-801 Equipment Decontamination
- SWE-FSOP-802 Investigation Derived Waste Management

Field Forms

- SWE-FFRM-004, Daily PFAS Sampling Checklist [PFAS Projects]

3.0 Equipment and Materials List

The list below identifies equipment expected to be used by staff while supervising excavation activities.

- A bound, waterproof field logbook (FLB; e.g., Rite in the Rain™ or similar) with pre-numbered consecutive pages for field documentation

  [PFAS Project]: Field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and cover can be used.

- Waterproof, indelible pens/markers in black or blue ink

  [PFAS Project]: Use ball-point pens. Do not use a marker, felt pen, or pen with water-resistant ink.

- Digital camera/video, cell phone, or other devices capable of digital imagery
- Appropriate PPE

The following materials are usually required for excavation monitoring. Review project-specific work plans for specific or unique materials or procedures.

- Measuring tape
- Plastic sheeting to protect decontaminated excavation equipment as necessary, as well as sampling equipment

  [PFAS Project]: Clean sampling equipment and containers should be stored within a protective medium (e.g., HDPE bag) or staged in a clean area for future use.

- Site-specific Test Pit/Trench Plan and Activity Hazard Analysis (AHA):
  - For excavations or trenches greater than 5 ft (1.5 m) in depth, both an excavation/trenching plan and AHA are required (EM-385-1-1, Section 25.A.01(a))
  - For excavations/trenches less than 5 ft (1.5 m) in depth or made entirely in stable rock, an AHA is required, and the excavation/trenching plan is optional (EM-385-1-1, Section 25.A.01(b))
- Test Pit/Trench sampling requirements
- Field activity and sampling forms, field logbook

- Waterproof black ink pens
- Backhoe and other specified excavating machinery
- Shovels, picks, or scoops
- Personal protective equipment as specified in site-specific APP/SSHP
- Appropriate field measurement instruments
- Decontamination supplies and equipment
- Sample containers
- Sampling equipment
- Coolers and ice
- Rinse bottles of potable water
- IDW containers as appropriate for storage of contaminated and potentially hazardous materials

4.0 Procedures

Procedures are provided for:

- Pre-Fieldwork tasks (Section 4.1)
- Mobilization and Set-Up (Section 4.2)
- Test Pit/Trench Excavation (Section 4.3)
- Sampling of Test Pits and Trenches (Section 4.4)
- Backfilling Test Pits and Trenches (Section 4.5)
- Demobilization/Site Restoration (Section 4.6)

4.1 Pre-Fieldwork Tasks

It is essential to be thoroughly familiar and compliant with standards and guidance regarding the recognition of soil types (i.e., A, B, and C soils), competency, trench construction guidelines, and emergency procedures. The Competent Person will determine the soil type encountered and identify appropriate measures, including the excavation process, support/stabilization requirements, material and personnel setback distances, etc.

4.1.1 Clearances

Before starting any intrusive activity, confirm that excavation locations have been appropriately cleared of potential overhead, surface, and subsurface hazards per the project work plans.

- Clearances should include a utility locating subcontractor to identify subsurface infrastructure and anomalies and conform to the facility manager's requirements if one exists.
- The clearance process also includes completing public utility locating service calls (e.g., Dig Alert, USA North 811, etc.) and completing any coordination and permitting procedures with the appropriate onsite personnel (e.g., Department/Directorate of Public Works).
- Aboveground utilities (e.g., electrical, cable, telephone lines) shall be identified and assumed to be energized ("live") unless confirmed de-energized. All equipment shall be kept a minimum of 10 feet from energized lines. For higher voltage lines or if minimum clearance cannot be maintained, obtain direction from the Program Manager/Project Manager and Safety Representative before proceeding.

- Review available forms and diagrams that document the selected location of the excavation location relative to underground/overhead utility lines, surface structures, or buried objects.
- Copies of the site clearance documents should be kept onsite.

4.1.2 Health and Safety

- Hold Tailgate Safety Meetings in the manner and frequency stated in the APP/SSHP.
- All personnel at the site should have appropriate training and qualifications per the APP/SSHP. Employees designated to perform the duties of an excavation Competent Person (CP) will have received training on the contents of this procedure and additional training on the responsibilities, duties, and performance of tasks required of a CP.
- All personnel within the exclusion zone should pay close attention to equipment operations during excavation. The moving equipment components can snag or catch loose clothing or strike personnel and cause severe injury or death.
- Establishing clear communication signals with the excavation crew is mandatory since verbal signals may not be heard during the excavation process. The entire crew should be made aware to inform the operator of any unforeseen hazard—or when anyone is approaching the exclusion zone.

4.1.3 Site Conditions and Excavation Logistics

Prepare the site per the project work plans. Before mobilizing, determine the logistics of excavating, logging, sampling, spoils placement and storage, and trench construction. The FTL or the Field Geologist/Engineer should assess the excavation site with the operator. This assessment should identify potential hazards (i.e., slip/trip/fall, overhead power lines) and determine how excavation operations may impact the environment (i.e., dust, debris, noise). As per the project work plans, potential hazards should be evaluated and corrected, or the trench/test pit location should be changed or shifted.

- Excavation site space requirements commonly include an area for the equipment and swing-out clearances, access for a dump truck, and possibly a forklift carrying shoring equipment, etc.

  [PFAS Project]: If there is a potential to cross-contaminate environmental media, lubricating compounds used on equipment should be confirmed in advance not to contain PFAS or other compounds incompatible with project objectives, laboratory analyses, or quality guidelines

4.1.4 Equipment Decontamination and Preparation

- All excavation and sampling equipment should be decontaminated before proceeding per SWE-FSOP-801. “Equipment Decontamination”
- Mechanized equipment shall be inspected for proper maintenance and appropriate decontamination before each time the equipment is mobilized to a site
- All moving parts and hydraulic hoses should be in good condition
- Any observed leakage of fluids from equipment should be immediately repaired and decontaminated again before it is allowed to mobilize

4.1.5 Calibrations

Before mobilization, calibrate the safety-related sampling and monitoring equipment.

4.1.6 Personal Protective Equipment (PPE)

Provide workers with the appropriate PPE as specified by the APP/SSHP.

4.2 Mobilization and Set-Up

The standard procedure for excavation is described below, and the project work plan may include additional specifications.

4.2.1 Site Preparation

The logistics of excavation, movement between locations, containing wastes, and placement of excavated material should be determined before mobilizing. The site should be prepared as per the project work plans.

- As per the APP/SSHP, appropriate barriers and markers should be in place before excavations begin
- Plastic sheeting (e.g., Visqueen™) may be required beneath equipment
- Appropriate spoils/investigation derived waste containment (e.g., drums, bins, plastic sheeting) should be set onsite before the commencement of excavation
- Clear the work site of all brush and minor obstructions and then mobilize equipment to the work location

4.2.2 Discussion of Site Conditions

Before excavation operations begin, the following must be completed:

- The FTL or Field Geologist/Engineer should assess the site with the operator. This assessment should identify potential hazards and determine how excavation operations may impact the environment.
- As per the project work plans, potential hazards should be evaluated and corrected, or the borehole location should be changed or shifted.
- If a shallow subsurface hazard (i.e., unidentifiable utility or trapped vapors) may exist, the operator should be informed of the potential hazard before breaking ground. Excavation should then commence slowly to allow continuous visual inspection and monitoring and, if necessary, stop for probing.

4.2.3 Mobilization

Once the site is prepared, mechanized equipment, if used, is mobilized and placed in the proper position to complete excavation.

- The backhoe should be secured before excavation, usually by deploying stabilizer arms and placing the front loader bucket on the ground.
- The operator should always check areas adjacent to and above the equipment and the swing radius relative to personnel, obstructions, or other hazards.

4.3 Test Pit/Trench Excavation

Entry into a test pit/trench should be avoided unless necessary and is prohibited when depths are over 4 feet. The Safety Representative and Competent Person must evaluate conditions and confirm that entering a test pit/trench is safe.

Test pits and trenches will be constructed manually or using mechanical equipment such as a backhoe. Mechanical equipment will be used when the investigated area is large and readily accessible. In small areas or areas where there is evidence that the suspected target is shallow, manual excavation with a shovel is preferred.

All excavations must be performed in compliance with the applicable safety regulations. The Safety Representative must ensure compliance with the appropriate regulations.

The following steps should be taken for the construction of the test pit/trench:

- Determine if excavated material can be placed directly into a dump box, on the ground, or plastic sheeting adjacent to the test pit location. Any excavated soil suspected to be contaminated, containing debris, or saturated must be placed on the plastic sheeting or other surface specified in the work plan.
- Place excavated materials at an appropriate distance from the edge of the excavation to prevent the material from falling into the excavation. A minimum of two feet from the edge is needed under all circumstances.
- Take all appropriate steps for the handling and containment of excavated material, including material placed in containers for waste characterization and disposal or returning it to the pit or trench if approved.
- Start excavation of the pit or trench using the equipment and machinery at least a few feet away from any identified anomaly. Manual methods (e.g., shovel) are recommended when excavation closer to the anomaly is necessary.
- Field conditions may necessitate changes in the planned excavation. In coordination with the PL and/or FTL, the CP will determine the exact depth and construction of the pit(s) or trench(es).
- Photograph all significant features exposed by the test pit/trench. Record all pertinent information from each photograph per FSOP-001, "Fieldwork Documentation."
- Test pits should not be left open overnight unless necessary. Refer to the work plan and APP for appropriate procedures for covering excavations. If excavations must be left open, the area around the hole will be secured as appropriate.

4.4 Sampling of Test Pits and Trenches

Entry into a test pit/trench should be avoided unless necessary and is prohibited when depths are over 4 feet. The Safety Representative and Competent Person must evaluate conditions and confirm that entering a test pit/trench is safe.

Trench and test pit sampling may be conducted to determine soil types and characteristics, levels, distribution, and migration pattern(s) of contaminants.

- Obtain surface samples required by the site-specific plan before excavation starts.
- Obtain subsurface samples during excavation as required by the site-specific work plan/QAPP.

- Sampling devices with extension handles may be used to obtain samples from the bottom or sides of the test pit or trench if done safely.
- Sampling from a backhoe bucket should be performed when conditions and safety requirements preclude the collection of samples directly from the walls or bottom of the excavation using manual sampling tools. Samples collected from the backhoe bucket should be performed according to site-specific work plans, which may include collecting from the center of the bucket or being biased toward suspected contamination.
- When sampling from a backhoe bucket, confirm it is safe to approach the bucket before collecting the sample (e.g., bucket on the ground, engine off, operator confirmation).
- Decontaminate sampling equipment after collection of each sample.

4.5 Backfilling Test Pits and Trenches

The following steps must be followed when backfilling test pits and trenches:

- Backfilling activities should be performed as soon as possible after collecting all data, photographs, and samples.
- If imported material is used as backfill, the material should be confirmed clean and approved for use in advance, which may include, but is not limited to, laboratory analysis, client approval, and regulatory agency concurrence.
- If a low permeability layer has been penetrated during excavation, ensure that the backfill material represents the original conditions of the excavated material or is impermeable.

  Note: Unique compaction requirements may apply to match original soil conditions.
- Complete backfilling according to work plans which may include placing in lifts and specific compaction requirements (e.g., track- or wheel-compacting, use of compaction equipment to specified limits, physical testing, etc.)
- Grade the surface to original conditions and promote appropriate drainage unless the project requirements specify otherwise.

4.6 Demobilization/Site Restoration

All debris generated by excavation activities should be disposed of appropriately. The site should be cleaned, the ground washed as necessary, and the site conditions restored per the project work plans. Any hazards remaining due to excavation activities should be identified, and appropriate barriers and markers should be put in place, as per the APP. All soil cuttings and fluids should be adequately contained, clearly labeled, and maintained to comply with the project work plans.

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control Method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for review of excavation field documentation will be performed by the FTL or PL to check that procedure, and documentation content and level of detail comply with this SOP. If a deficiency or a variance was taken to the SOP, the PL should document the deficiency/variance and determine the need for corrective action in coordination with the QA Manager.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained, and revisions to an entry should be signed and dated by the FTL.

The PL is responsible for reviewing and signing final approved documents stored in the project file.

7.0 References

United States Army Corps of Engineers, 2014 (or most current version). *Manual No. EM385-1-1, Safety and Health Requirements.* November 30.

Equipment Decontamination

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Christopher Ohland — October 10, 2022
Christopher Ohland — Date
SWE Quality Assurance Manager

Bruce Wilcer — October 10, 2022
Bruce Wilcer — Date
SWE Field Quality Control Manager

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Rev 1, 10/10/2022: Revised to include PFAS-friendly supplies and procedures

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques and documentation requirements to decontaminate field equipment and personal protective equipment (PPE). Decontamination is necessary to prevent sample cross-contamination, exposure to contaminants, and unintended contaminant transport.

Equipment is decontaminated so that environmental contaminants are not transported offsite or across boundries defining a contaminant mass. Equipment that comes into contact with contaminants are decontaminated to minimize cross-contamination of multi-media samples. These samples are packaged and submitted for laboratory tests, where, in most instances, the laboratory performs sub-part per million tests; thus, care must be taken to minimize cross-contamination of the collected sample.

1.2 Scope

The scope of this SOP applies to field staff working with sampling equipment that comes into contact with environmental contaminants. The SOP also address activities that use industrial equipment such as drill rigs and tools and activities that use larger equipment such as trucks, loaders, excavators, and others.

Decontamination procedures described here are applicable to fieldwork involving modified Level D PPE (steel-toed boots, hard hat, safety glasses, and disposable nitrile gloves) where contact with hazardous substances is limited.

When required by the project, use the PFAS-free equipment, materials, and procedures recommended in this SOP which are indicated by [PFAS Project].

1.3 Responsibilities

Field Team. A Field Team is one or more individuals working together. The Field Team is responsible for the oversight of and/or collection of groundwater samples as specified in this SOP.

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of USACE EM-385-1-1 (USACE, 2014). The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the PL of safety deficiencies and incidents and actions to correct those. The PL approves those actions or notifies the Site Safety and Health Officer for their approval if the circumstance warrants involvement.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Exclusion Zone. Location at a site delineated by the presence of contamination or where contamination is suspected. The outer boundary of the Exclusion Zone is identified as the "Hotline," and is commonly marked with placards, hazard tape, or signs.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

Contamination Reduction Zone. A location outside the Hotline designated for decontamination of equipment and personnel that serves as the transition between contaminated and clean areas.

PFAS-free water – Water purchased as certified PFAS-free or water taken from a municipal water system or waterwater supply well that approved for use. Typically, the water is sampled for PFAS tests and demonstrated to be PFAS free or concentrations that are low enough for the Data Quality Objectives defined for the project (i.e., PFAS may be present but at acceptable concentrations.

Support Zone. A location outside of the Contamination Reduction Zone that is not expected to be contaminated and is upwind of suspected contaminants. The Support Zone commonly contains administrative and support personnel, field offices, facilities, etc.

Investigation Derived Waste (IDW). Waste that may be classified as hazardous or non-hazardous and is generated during site-related work.

Personal Protective Equipment (PPE). Personal health and safety equipment used to protect an individual from contaminant exposure and physical injury.

2.0 Relevant Documents

Field SOPs

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-802, Investigation Derived Waste Management

Field Forms

- SWE-FSOP-004, Daily PFAS Sampling Checklist [PFAS Projects]

3.0 Equipment List

- Bound FLB with consecutive page numbers and waterproof, indelible pens/markers

  [PFAS Project]: Use field logbook made of standard/loose plain paper (non-weatherproof), held together by an aluminum or Masonite field clipboard. Alternatively, a spiral-bound notebook with non-weatherproof paper and/or cover can be used.

- Gloves (select type based on activity and hazard)

- Brushes, typically stiff bristle
- Plastic buckets or tubs
- Anionic detergent (Liquinox™, or similar)
- Spray or rinse bottles, or pump sprayer
- High-pressure hot water sprayer for cleaning large equipment
- Face shield
- Splash protection/apron/Tyvek™

    [PFAS Project]: Use uncoated HDPE suits (e.g., certain Tyvek® products)

- Waste containers for IDW (see SWE-FSOP-802)
- Paper towels
- Clean tap water

    [PFAS Project]: PFAS-free potable water

- Distilled water

    [PFAS Project]: Laboratory-certified PFAS-free deionized water

- Garbage bags
- Plastic sheeting

4.0 Procedures

Procedures are provided for:

- Pre-fieldwork tasks (Section 4.1)
- Decontamination relative to four different aspects of work (Section 4.2 to 4.6)

Document control (Section 4.7)

4.1 Pre-Fieldwork Tasks

Identify an onsite decontamination area(s) for small items (e.g., sampling equipment, hand tools, etc.) as well as larger equipment such as drill rigs and tooling, trucks, loaders, excavators, and others. Select the area(s) so that decontamination fluids and soil wastes can be managed in a controlled area with minimal risk to the surrounding environment.

Decontamination is critical for maintaining the integrity of a sampling program. Check equipment carefully prior to sampling, and if there is any doubt about the effectiveness of the decontamination, repeat the decontamination process as an extra precaution.

Decontaminate all non-disposable sampling equipment prior to use. Decontaminate industrial equipment used in investigation such as geophysical equipment, drill rigs and tooling, and others before their use at a site.

If equipment will not be used immediately, establish means of storage that maintain the cleanliness of equipment. That may be suspending equipment off the ground or wrapping in a protective material.

Identify the types and locations of IDW containers before generating IDW from decontamination activities.

4.2 Decontamination Area

The decontamination area should be large enough to allow temporary storage of cleaned equipment and materials before use, as well as to stage drums and bins of IDW. In the case of large decontamination areas (for example, for hollow-stem auger decontamination), line each area with heavy-gauge plastic sheeting and include a collection system designed to capture potential liquid and solid decontamination IDW. Lay out decontamination areas in such a way as to prevent overspray while performing equipment and personnel decontamination.

Smaller decontamination tasks, such as surface water and sediment sampling equipment decontamination may take place at the sampling locations. In this case, all required decontamination supplies and equipment must be mobilized to the site, and smaller decontamination areas for personnel and portable equipment provided as necessary. These locations will include basins or tubs to capture decontamination IDW, which will be transferred to larger containers as necessary.

4.3 Personnel and PPE Decontamination

Personnel decontamination first involves the removal of gross contamination. Scrape and wipe contaminated solids such as mud from the outermost layer of protective clothing and boots, and remove gloves by rolling off the hands starting at the cuff in such a way that the gloves are turned inside out during removal. If necessary, don a clean pair of gloves to complete the boot cleaning process. Boots can be cleaned while being worn or following removal. Remove any remaining contamination using soapy water, brushes, or other similar means such as a pressure washer, if available.

Once all debris is removed, rinse PPE with clean water.

[PFAS Project]: Once all debris is removed, PPE should be rinsed with clean PFAS-free potable water.

If boots are dry and not laden with gross solid materials, a brush can simply be used to knock off or remove any residual solid materials. If the boots have contacted liquid phase contaminants, it is important that the contaminants be removed using soapy water and a brush, followed by a clean water rinse. If the contaminants have adsorbed into the boots, the boots must be disposed of and a replacement pair obtained before conducting any further field activities.

Following removal and cleaning of reusable PPE, field personnel should wash their hands or any exposed body parts which may have been in contact with the associated hazardous substances.

***Note**. Disposable PPE such as gloves and suits that have no visible solids (lightly soiled) may not need to be cleaned as described above. If the PL approves, these PPE items are disposed in accordance with SWE-FSOP-802, "IDW Management."*

4.4 Sampling and Hand-Held Equipment Decontamination

4.4.1 Pre-Sampling

1. Consolidate containers and equipment for decontamination. Decontaminate new and not-previously-decontaminated equipment/material before use. If the prior use is unknown, assume the equipment/material needs to be decontaminated.

[PFAS Project]: Wash water-resistant equipment thoroughly and vigorously with PFAS-free potable water containing laboratory-grade detergent (Alconox, Liquinox, or Citranox) and a polyethylene or polyvinyl chloride (PVC) brush. Rinse equipment thoroughly three times with certified PFAS-free deionized water or another source acceptable for project use.

2. Unless the equipment will be used immediately, wrap in new aluminum foil, plastic, or other appropriate material to keep it clean until needed. For large bulky equipment, clean plastic sheeting can be substituted for aluminum foil. If the protective wrapping on a piece of pre-cleaned equipment has been torn or if there is a question of its cleanliness, the equipment should be considered contaminated and undergo full decontamination procedures before use.

   [PFAS Project]: Do not use aluminum foil, as PFAS are sometimes used as a protective layer.

4.4.2 Post-Sampling

This section applies broadly to all hand tools (trowels, bowls, hand augers, slide hammer samplers, and other specialized and non-specialized tools), as well as meters and gauges (multimeters, water-level indicators, etc.). All non-disposable sampling equipment should be cleaned prior to the next use.

Follow these cleaning procedures:

1. Remove as much gross contamination (such as pieces of soil) as possible from equipment at the sampling site.
2. Wash water-resistant equipment thoroughly and vigorously with potable water containing detergent such as Liquinox or equivalent, and use a bristle brush or similar utensil to remove any remaining residual contamination.
3. Rinse equipment thoroughly with potable water (1st rinse).
4. Rinse equipment thoroughly with distilled or deionized water (2nd rinse).
5. For sensitive field instruments, rinse equipment with distilled, deionized, or reagent grade water (3rd rinse).

   ***Note**: Rinse waters are not reused and should be discarded in an appropriate IDW container.*
6. Air dry at a location where dust or other fugitive contaminants will not contact the sampling equipment. Alternatively, wet equipment may be dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.

   ***Note**: For non-dedicated bladder pumps used during sampling, reusable pump components should be decontaminated using steam cleaning and/or Steps 3 through 6 above. Insert a new bladder into the pump housing and use new tubing cut to the required length between each monitoring well sampled. Do not reuse wetted components. Follow the bladder pump manufacturers' guidelines and specifications for changing wetted components in between sample points.*

   ***Note**: For rigs and variable speed pumps used during well development, all wetted components shall be steam cleaned and rinsed using clean potable water.*

   [PFAS Project]: In cases where dry decontamination is required, the following steps shall be followed at the sampling site:

   1. Remove as much debris or contamination as possible using a dry polyethylene or PVC brush or paper towel.

2. Spray equipment with water mixed with Alconox or Liquinox.
3. Wipe down with a clean, dry paper towel.
4. Spray equipment with laboratory-certified PFAS-free water.
5. Wipe down with a clean, dry paper towel.
6. Repeat Steps 4 and 5 twice more (for a total of three rinses with laboratory-certified PFAS-free water).

Store clean, dry sampling equipment within a protective medium (e.g., plastic bag, etc.) or staged in a clean area for future use. Cleaning and decontamination wastes must be properly contained and disposed of in accordance with project IDW management procedures. Use disposable sampling equipment whenever possible (e.g., drum samplers, bailers, spoons, etc.) to minimize the need to decontaminate these items.

4.5 Large Equipment Decontamination

Perform gross decontamination of large equipment before delivery to the site, before transporting equipment from one contaminated location to another, and before leaving the site.

Gross decontamination focuses on minimizing the spread of contaminated media as a result of equipment movement or transport. This decontamination process uses dry methods (brooms, wipes, shovels, etc.) within the exclusion zone in order to remove large, easily dislodged deposits of soil and other contaminated media prior to exiting the exclusion zone.

When equipment is no longer needed and will be removed permanently from the site, it shall be decontaminated using brushes and/or a pressure washer with a detergent wash followed by a water rinse.

> [PFAS Project]: To the extent practical, rinse parts of equipment that come into direct contact with samples with PFAS-free water. When equipment is no longer needed on site and will be removed permanently from the site, it shall be decontaminated using brushes and/or a pressure washer with Alconox, Liquinox, or Citranox wash followed by a triple rinsing with PFAS-free water rinse.

Final decontamination shall occur within a decontamination pad to allow for the collection of decontamination materials, solids, and water.

Additionally, large equipment should be free of leaks (i.e., hydraulic fluid, oil, gas, etc.) that could become a source of contamination.

4.6 Dry Decontamination

In cases where dry decontamination or larger equipment is required, follow this procedure at the site:

1. Remove as much debris or contamination as possible using a dry brush, broom, shovel, or paper towel.
2. Check crevices, tire treads, hinges, and other surfaces that may trap contaminants; remove visible residue with a brush, scraper, etc.
3. Inspect all surfaces and, where necessary,wipe them down with a clean, dry paper towel as a final step.
4. Dispose of all paper towels with other IDW and disposable sampling supplies.

4.7 Document Control

After a task or project, all field documentation, including the field logbook/notepads, field forms, and electronic data, shall be scanned and placed on the server in the appropriate folder. All original documents shall be submitted to the PL and kept in the project file. See FSOP-001 (Field Documentation).

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

6.0 Documentation Review

The FTL is responsible for the daily review of the fieldwork documentation for compliance with requirements (Section 4.0 "Procedures") and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

Not applicable.

Investigation Derived Waste Management

Document Number	SWE-FSOP-802
Revision	0
Department	Southwest Operations
Previous Document Number	Original Document
Originally Released	April 1, 2022
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Approvals

Christopher Ohland
SWE Quality Assurance Manager

April 1, 2022
Date

Bruce Wilcer
SWE Field Quality Control Manager

April 1, 2022
Date

Project-Specific Modification[1]

[1] Document project-specific modifications in this section. No other modification to the SOP is authorized.

Revision History

Table of Contents

1.0 Introduction

1.1 Purpose

The purpose of this standard operating procedure (SOP) is to direct field staff in the proper techniques, and documentation for handling, labeling, tracking, and disposing of investigation derived waste (IDW) encountered or generated during environmental field activities. This SOP gives descriptions of equipment, field development procedures, field data collection, and personnel responsibilities.

1.2 Scope

The scope of this SOP is to describe procedures for projects that generate IDW.

Materials that may become IDW include but are not limited to:

- Personal protective equipment (PPE) includes disposable coveralls, gloves, booties, respirator canisters, splash suits, and other non-soil, solid wastes
- Disposable equipment and items include plastic ground and equipment covers, aluminum foil, conduit pipe, disposal samplers (e.g., bailers), tubing, and others
- Soil cuttings/spoils from boreholes/trenches and other soil wastes generated during sampling
- Drilling mud or water used or generated during drilling
- Groundwater obtained through well development or well purging
- Cleaning fluids such as spent solvents and wash water
- Packing and shipping materials
- Sediment from surface water bodies (rivers, lakes, ponds)
- Wash and rinse waste from decontamination activities

These types of IDW may require classification as non-hazardous or hazardous waste and should be containerized, stored, profiled, transported, and disposed of appropriately according to regulatory and client-specific requirements. Review project-specific work plans and waste management plans to confirm appropriate procedures for each site.

1.3 Responsibilities

Field Team. A Field Team is one or more individuals working together. The Field Team is responsible for the oversight of IDW as specified in this SOP.

Field Team Lead (FTL). The FTL is responsible for reviewing project work plans to understand the health and safety needs, procedural specifications, and field documentation requirements. The FTL is responsible for reviewing and confirming the adequacy of the fieldwork documentation.

Project Lead (PL). The PL is responsible for providing adequate resources to the field staff and ensuring the Field Team has adequate experience and training to comply with the SOP successfully. The PL is responsible for approving and documenting techniques not described in this SOP but are considered the best methods for the current project.

Safety Representative. The Safety Representative meets the experience and training requirements of USACE EM-385-1-1 (USACE, 2014). The Safety Representative oversees site-specific health and safety activities and ensures compliance with the project requirements. The Safety Representative notifies the

FTL of safety deficiencies and incidents and actions to correct those. The FTL approves those actions or, if the circumstance warrants, notifies the PL and Site Safety and Health Officer for their approval.

Quality Control Lead (QC Lead). The QC Lead ensures work inspections are performed using the 3-Phases of Quality Control method described in the project work plans. The QC Lead notifies the PL of quality deficiencies and actions to correct those. The PL approves those actions or notifies the SWE Field QC Manager for their approval if the circumstance warrants involvement.

1.4 Definitions

Field Documentation – The combination of field logbooks/notepads, field forms, digital/electronic forms, and other documentation in the project file.

Field Forms – Any documentation that preserves an accurate historical record of field activities but is recorded on unbound paper. These forms should be referenced in the FLB. Each data entry field should have an entry or indicate that data for that field is not available or not required.

Field Logbook (FLB) – A portable, bound, weatherproof notebook with consecutively numbered pages.

Field Notepad – A unbound notepad or loose-leaf paper with consecutively numbered pages.

Investigation Derived Waste (IDW). Waste that is generated in the process of investigating or examining a contaminated site.

Personal Protective Equipment (PPE). Personal health and safety equipment is used to protect the individual from contaminant exposure and physical injury.

2.0 Relevant Documents

This SOP focuses on the IDW management task and applications and should be used in conjunction with other applicable SOPs and forms, including the following:

2.1.1 Standard Operating Procedures

- SWE-FSOP-001, Field Documentation
- SWE-FSOP-801, Equipment Decontamination

3.0 Equipment List

The following materials and equipment may be needed for IDW management:

- Bound field logbook (FLB) with consecutive page numbers and waterproof, indelible pens/markers
- PPE as outlined in site-specific Accident Prevention Plans (APPs)
- Decontamination equipment and supplies (e.g., wash/rinse tubs, brushes, Liquinox™, plastic sheeting, paper towels, sponges, garden-type water sprayers, large plastic bags (minimum 0.85 mil), potable water, distilled water, and deionized water)
- Department of Transportation (DOT)-rated 55-gallon drums or other approved containers for containing soil cuttings, decontamination water, and formation water
- Drum/bung wrench and drum funnel

- Heavy equipment forklift or vehicle with drum grappler (as necessary)
- Photoionization detector (PID)
- Vendor-supplied roll-off bin(s), with liners if applicable
- Laboratory-supplied sample containers
- Wood pallets (as necessary)
- Non-porous (e.g., stainless steel) trowels
- Field notebook/notepad and waterproof permanent marking pens
- Waste manifests
- Secondary containment materials (i.e., spill containment platform/pallet with drain, absorbent pads)

4.0 Procedures

The procedures below are provided for managing non-liquid and liquid IDW generated during field activities.

4.1 IDW Staging Area

Identify an onsite area for staging drums, bins, and other storage containers. The area should be large enough to allow temporary storage and safe access to the drums and bins of IDW. If IDW is left onsite without supervision, then the area must be secured from unauthorized access and containers labeled appropriately. Hazardous IDW may not be accumulated for more than 90 days.

4.2 Soil IDW

Place IDW (soil cuttings/spoils generated during drilling, trenching, soil sampling, or other) into DOT-rated 55-gallon drums, appropriately-sized containers/bins, or stockpiles at the point of generation. In most cases, mixing the cuttings from several borings or sampling locations is permissible to fill the containers or entire stockpiles but must be confirmed in advance by the PL/FTL. Ask the FTL whether potentially hazardous solids should be segregated from non-hazardous.

When drums or containers are full or daily activities are completed, the drum lids and rings will be fastened. Full drums or containers will be transported to the designated IDW accumulation area regularly to avoid the accumulation of drums or containers at investigation sites for extended periods.

Waste profiling analyses will be performed before disposal (Section 4.5). Each project may have unique waste profiling, storage, and disposal—review project-specific work plans and coordinate activities between the PL and client.

Unless approved, hazardous soil cuttings and excavation spoils must not be used to fill boreholes, test pits, or excavations. Place soil cuttings/spoils on plastic sheets or containerize them when generated; dispose of the plastic sheets with the used PPE or soil cuttings.

4.3 Liquid IDW

Contain liquids in DOT-rated drums or appropriately-sized watertight containers at the point of generation. Mixing the water from several sampling locations, decontamination water, process water, and other IDW sources may be permissible to fill the drums but should be confirmed in advance with the PL or FTL. Ask the FTL whether potentially hazardous liquids should be segregated from non-hazardous.

When drums or containers are full or daily activities are completed, the drum lids and rings will be fastened. Full drums or containers will be transported to the designated IDW accumulation area regularly to avoid accumulating drums or containers at investigation sites for extended periods. All drums or containers will be labeled appropriately at the end of each day’s activities. Perform waste profiling before disposal (Section 4.5). Each project may have unique requirements for waste profiling, storage, and disposal—review project-specific plans and coordinate activities with the PL or FTL.

4.4 PPE and Other Consumable Supplies

Inspect equipment and PPE (e.g., plastic sheets, screens, coveralls, boot covers, or other) to determine proper disposal procedures. If there is no evidence of contamination, materials can be disposed of with regular trash.

Decontaminate and discard PPE and other used supplies in plastic bags and sealed in metal barrels for final storage, transport, and disposal. Decontamination procedures consist of brushing off or using small amounts of water to scrub off potential gross contamination (see SWE-FSOP-801, Equipment Decontamination).

4.5 Waste Profiling

Waste profiling requirements will be coordinated by the PL with the client and disposal facility. At a minimum, a representative sample of the solid and aqueous IDW will be collected and analyzed for all chemicals of potential concern. When approved by the PL, generator knowledge is an acceptable alternative to laboratory testing. The PL will also coordinate with the client, disposal facility, and waste transporter to manage the completion of the waste manifest and ensure that an adequate number of manifests are available for the amounts and types of material to be disposed of. An example manifest is provided in Attachment 1.

Waste manifests are signed by the client or client’s representative (usually identified on the manifest as the “owner” and/or “generator”). Field personnel are not allowed to sign manifests under any circumstances.

4.6 Labeling

Apply a label immediately after adding soil or groundwater to drums or soil to bins. If the waste generated has not been profiled, apply a “Pending Analysis” label (Figure 1). Add the contents, date(s) of generation, the origin of materials, address of generation, and contact information to the label. Because drum and container labels may be exposed to the elements, it is essential to use waterproof markers to fill in the information on labels and possibly clear packaging tape over the labels to preserve the information.

Once the material has been profiled, remove the “Pending Analysis” label and add the appropriate “Non-Hazardous” (Figure 2) or “Hazardous” label (Figure 3). Add the shipper, address, date(s) of generation, contents, and contact information to the label.

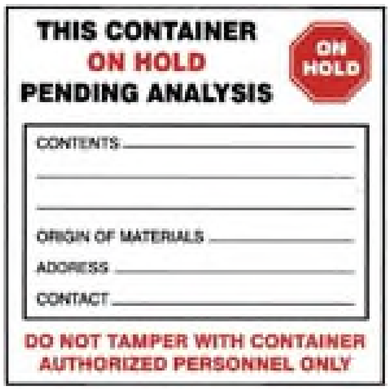

Figure 1 – Label: Pending Analysis

Figure 2– Label: Non-Hazardous

Figure 3– Label: Hazardous

4.7 Disposal of IDW

Soil and groundwater IDW will be placed in drums or appropriately configured bins and stored in a designated hazardous/non-hazardous waste storage area, the location and use of which will be coordinated with the client. Manifesting and disposal of IDW during field activities will be coordinated with the client before the initiation of field activities. As applicable, field activities that generate IDW will be conducted consistent with sustainable practices (e.g., reducing the volume of routine waste or IDW generated by decreasing materials consumption).

4.8 Document Control

The FTL is responsible for documenting or reviewing field team documentation of IDW management, including collection, sampling, labeling (if applicable), staging, and ultimate disposition of IDW. Disposition may include manifesting the waste and transportation offsite or releasing the waste to the client for ultimate disposal. The information entered in field documentation concerning IDW should include the following:

- Project Name
- Names of personnel
- Site location
- Type of activities
- Date waste generated
- Boring, well, or site number(s)
- Matrix
- Type of container(s)
- Estimated volume
- Disposition of contents
- Comments (field evidence of contamination [e.g., PID reading, odors])
- Any variance to procedures described in this SOP

After completing a task or project, all field documentation, including the field logbook, field datasheets, and electronic data, shall be scanned and placed on the server in the appropriate folder. All original documents shall be submitted to the PL and kept in the project file. See FSOP-001 (Field Documentation).

5.0 Quality Assurance/Quality Control

Conduct the 3-Phases of Quality Control method described in the project work plans.

Quality Assurance (QA) and Quality Control (QC) procedures for IDW field documentation review will be performed by the PL and QC Manager to confirm that content and level of detail comply with the applicable planning documents. Identification of errors and corrections made during QA/QC reviews will follow documentation requirements described in SWE-FSOP-001 (Fieldwork Documentation).

6.0 Documentation Review

The FTL is responsible for reviewing hazardous waste characteristics, ensuring the disposal facility is licensed to receive the IDW, and reviewing waste manifests and bills of lading.

The FTL is responsible for the daily review of fieldwork documentation for compliance with requirements (Section 4.0) and legibility. Errors and omissions should be explained and revisions to an entry signed and dated by the FTL.

7.0 References

None cited.

Attachments

Attachment 1.
Uniform Hazardous Waste Manifest

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) **A7 2002939203-001** **SC PPW 12/9/2008** Form Approved. OMB No.2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST	1. Generator ID Number	2. Page 1 of 1	3. Emergency Response Phone	4. Manifest Tracking Number

5. Generator's Name and Mailing Address | Generator's Site Address(if different than mailing address)

Generator's Phone:

6. Transporter 1 Company Name | U.S.EPA ID Number

7. Transporter 2 Company Name | U.S.EPA ID Number

8. Designed Facility Name and Site Address | U.S.EPA ID Number

Facility's Phone:

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group(if any))	10. Containers		11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
		No.	Type			

14.Special Handling Instructions and Additional Information

Contract retained by generator confers agency authority on initial transporter to add or substitute additional transporters on generator's behalf for purposes of transportation efficiency, convenience, or safety

15. GENERATION'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I Certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name | Signature | Month Day Year

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit :

Transporter Signature (for exports only): Date leaving U.S. :

17. Transporter Acknowledgement of Receipt of Materials

Transporter 1 Printed/Typed Name | Signature | Month Day Year

Transporter 2 Printer/Typed Name | Signature | Month Day Year

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator) | U.S. EPA ID Number

Facility's Phone:

18c. Signature of Alternate Facility (or Generator) | Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a.

Printed/Typed Name | Signature | Month Day Year

EPA Form 8700-22v (Rev. 3-05) Previous editions are obsolete.

Attachment G:
Habitat and Biological Monitoring Forms

SITE HABITAT CHECKLIST

The following are requirements to minimize biological disturbances to protected species and habitat. Please notify the Ahtna Biologist (Denise Duffy and Associates) at 831-373-4341 *before* proceeding, if work tasks or work boundaries change, additional vegetation removal is necessary, vegetation cutting methods change, or any other conditions change.

SITE:	University of California – Fort Ord Natural Reserve - South	**Date:**	XX-XX-2023
Work to be conducted:	Well decommissioning		

1. LAND USE:	☒ **Habitat Reserve**	☐ **Development Area**	☐ **Other (specify):**

2. LAND OWNER:	☐ **Army**	**Location:**	
	☐ **BLM**	**Location:**	
	☒ **Other:**	**Location:**	University of California, Santa Cruz

3. ENDANGERED SPECIES/	☐ **Yes**	☐ **No**	☐ **Flagged/Marked**
HMP Listed Species:			
Location:			
Grid Numbers:			

Restrictions:

- Restrict all vehicle access and staging to designated flagged routes, and staging areas.
- Stay on roads.
- Report all black legless lizard or California Tiger Salamander encounters to Ahtna field supervisor and biologist immediately.
- Coordinate with biologist first, if additional areas are needed for access or staging of equipment or vehicles.
- Contact number for Ahtna Biologist (Denise Duffy and Associates) is 831-373-4341.
- Contact number for the BRAC Office Biologist is 831-242-7918

4. VERNAL POOLS/PONDS PRESENT	☐ **Yes**	☐ **No**	☐ **Flagged/Marked**
Location:			
Grid Numbers:			
Work Can Proceed in Pools/Ponds:	☐ **Yes**	☐ **No**	

Restrictions:

5. VEGETATION REMOVAL	
☐ **No Removal Needed**	**Location:**
☐ **Manual Removal Needed**	**Location:**
Restrictions:	
☐ **Mechanical Removal Needed:**	**Location:**
Mechanical Removal Restrictions:	

6. EROSION CONCERNS/SITE RESTORATION:

7. SITE ACCESS:

8. ADDITIONAL SITE CONCERNS:

This checklist has been read, approved, and signed by the following:

☐ **Ahtna Biologist:** ____ **Date:** ___________

☐ **Ahtna Field Supervisor:** ______________________________ **Date:** ____________

☐ **Army Natural Resources Specialist:** __________________________ **Date:** ____________

Fort Ord Species of Concern Identification and Procedures

Fort Ord Animal Species of Concern

California Tiger Salamander (CTS) and Black Legless Lizard (BLL) are species of concern at Fort Ord. CTS are endemic to California and are a threatened species. CTS larvae are yellowish gray typically habitat in vernal pools and metamorphisms into adults in summertime growing to a 3 to 5 inch salamander with yellow spots. As adults during the day CTS spends time underground in animal burrows. BLLs are a California protected species that are small slender lizards 4 to 7 inches long with no legs which forages in loose soil, sand, and leaf litter during the day and may come to the surface at dusk and night. If a CTS or BLL is found, notify Base Realignment and Closure (BRAC) Biologist Bart Kowalski at (831) 595-5569 who will coordinate an approved Biologist to visit the site and handle and remove the CTS as necessary from the work area. BLL may be relocated by onsite personnel.

FONR Plant Species of Concern

There are two plant species in the Fort Ord Natural Reserve (FONR) which is owned by University of California, Santa Cruz (UCSC) with monitored populations, Sand Gilia and Monterey Spineflower. Stay on the driving paths in the FONR, do not drive where prohibited and try not to walk on species of concern plants. Both plants are annual herbs that are native and endemic to California and typically bloom starting in March/April through June/July, but depending on weather conditions may bloom earlier. FONR questions may be directed to Gage Dayton with UCSC at (831) 227-5887.

CA Tiger Salamander

Black Legless Lizard

Monterey Spineflower

Sand Gilia

Coast Horned Lizard

The California species of concern Coast Horned Lizard has a 4-inch rounded flat body, blunt snout, tail, and toad-like body with horns. When moving vehicles or heavy equipment into the inner roads of the northern FONR, have personnel walk in front of the vehicle as directed by UCSC to scare out Coast Horned Lizards that may be in the roadway before the vehicle passes. Notify Bart Kowalski of observances who will notify UCSC. Work does not need to be stopped if encountered, just relocated away from moving vehicles.

BIOLOGICAL OBSERVATION FORM – CTS/BLL

If a California tiger salamander (CTS) or black legless lizard (BLL) is found, notify Bart Kowalski, the BRAC Office Biologist. Only service approved biologist should fill out the CTS field observation form, and only service approved biologist can handle and move CTS out of the way. If CTS is encountered all work needs to stop until service approved biologist gets to the location and relocates the CTS. After completing this form attach a photograph of the specimen (if possible) and a map showing the location of the sighting, and return to BRAC:

Mr. Bart Kowalski
Building 4463, Gigling Rd, Rm 101, Monterey, CA 93944-5004
Office: (831) 242-7918 Cell: (831) 595-5569

Location ______________________________________ **Date/Time** ________________
(OE site, Range # etc)

Grid # ______________________ **Northing/Easting or Approx. Coordinates (ft)** ________________

Type of Activity (check one or write in)

- ☐ Well Installation/Drilling
- ☐ Vegetation clearance
- ☐ Other ____

Weather: Air Temp.__________ Wind ___________ Sunny/Cloudy ______________

Depth if known _________________

Habitat Description (e.g. Maritime chaparral, oak woodland, grassland, vegetation height, presence of surface litter/debris, soil type, plant species where specimen found, etc.):

____
____
____

Description of specimen (live/ injured/ dead, color, condition, behavior etc.):

____
____
____

Length (inches): ____

Other Notes: ____
____

Disposition: Found by: ____

- ☐ Observed, released to same location or adjacent habitat
- ☐ Observation form completed By:_________________________________
- ☐ Injured or killed (placed in a Ziploc or plastic bag, and refrigerated)
- ☐ Other ____

Attachments: ☐ Location map ☐ Photograph (specimen and habitat in which found)

Attachment H:
Responses to U.S. Environmental Protection Agency Comments on the Draft QAPP Addendum

Responses to U.S. Environmental Protection Agency Comments on the Draft QAPP Addendum[1]

GENERAL COMMENT 1: It is unclear why a potentiometric surface map was not presented to show the gradients and resulting flow directions in the Upper 180-Foot Aquifer. As such, whether cones of depression exist in the potentiometric surface around the operating extraction wells and the demonstration of groundwater capture is unclear. Please revise the QAPP to present figures of the potentiometric surface in the Upper 180-Foot Aquifer.

RESPONSE TO GENERAL COMMENT 1: *The report was not revised based on the comment. Potentiometric surface maps showing cones of depression around operating extraction wells are available in other reports that are referenced in the Quality Assurance Project Plan (QAPP) Addendum and are thereby incorporated by reference (e.g., see Administrative Record Nos. OUCTP-0105B and OUCTP-0113). Groundwater capture is demonstrated on figures presented in Attachment B to the QAPP Addendum.*

SPECIFIC COMMENT 1: Section 3.0, Worksheet #3 & 5, Project Organization and QAPP Addendum Distribution, Page 5: The box listing Ahtna subcontractors lists the analytical laboratory as "Analytical lab," but does not specify the name of the lab. Please revise this section to include the name of the analytical laboratory.

RESPONSE TO SPECIFIC COMMENT 1: *Worksheet #3 & 5 was revised per the comment.*

SPECIFIC COMMENT 2: Section 6.1.2, Worksheet #10: Conceptual Site Model, Potential Receptors and Exposure Pathways: Page 9: This section states "These supply wells are screened in the Lower 180-Foot Aquifer or deeper aquifers," but does not provide information describing the nature and depth of the deeper aquifers (e.g., 400-Foot Aquifer). Please revise this section to include further discussion of the nature and depth of the deeper aquifers.

RESPONSE TO SPECIFIC COMMENT 2: *The text was not revised based on the comment. The requested information is not relevant to the construction of new extraction well EW-OU2-13-180 as part of the remedy for Operable Unit Carbon Tetrachloride Plume (OUCTP) in the Upper 180-Foot Aquifer, which is the purpose of this QAPP Addendum.*

SPECIFIC COMMENT 3: Section 9.1.3, Worksheet #14 & 16: Project Tasks & Schedules, Utility Clearance, Page 19: This section states "Clearance activities include review of available utility maps, notification of utility agencies and/or utility protection organizations, as appropriate, and performing onsite surveys using the appropriate geophysical equipment;" however, the text does not provide details on the specific geophysical equipment that will be used, i.e., ground penetrating radar, etc. Please revise this section to provide a more detailed discussion of the proposed geophysical equipment that will be used.

[1] In a letter dated March 1, 2024 (see Administrative Record No. BW-2948.2). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

RESPONSE TO SPECIFIC COMMENT 3: *The text in Section 9.1.3 was revised to list the type of geophysical equipment that is expected to be used and to note that the work will be performed by a California licensed Professional Geophysicist.*

SPECIFIC COMMENT 4: Section 9.1.4, Worksheet #14 & 16: Project Tasks & Schedules, Habitat Clearance, Page 19: This section indicates that the onsite biologist will survey proposed project locations, access routes and staging areas; however, the text does not discuss the qualifications or certifications of the onsite biologist. Please revise this section to indicate the qualifications and certifications of the onsite biologist.

RESPONSE TO SPECIFIC COMMENT 4: *The text was revised per the comment.*

SPECIFIC COMMENT 5: Section 9.2.5, Worksheet #14 & 16, Project Tasks & Schedule, Page 23: This section states “The vault may be pre-cast or constructed on site,” but does not discuss the design specifications of either a pre-cast or constructed on site vault. Please revise this section to include a discussion for the design of both the proposed pre-cast and constructed on site vault.

RESPONSE TO SPECIFIC COMMENT 5: *Vault design is provided in the construction drawings in Attachment C and the text was revised to reference the appropriate drawings. The text in Section 9.2.5 already includes a reference to specifications for cast-in-place concrete in Attachment D. Additional design specifications in the text would be unnecessarily redundant.*

SPECIFIC COMMENT 6: Section 9.4.2, Worksheet #14 & 16, Project Tasks & Schedule, Investigation-Derived Waste – Soil , Page 33: This section states “Soil IDW [Investigation-Derived Waste], including soil generated from drilling, will be contained in drums or bins onsite and will be characterized and disposed of in accordance with applicable laws and regulations,” but does not provide any further detail of the sampling required by the applicable laws and regulations. Please revise this section to include a discussion of the requirements presented by the applicable laws and regulations.

RESPONSE TO SPECIFIC COMMENT 6: *The text “applicable laws and regulations” was deleted because the characterization and disposal methods are described in detail subsequently in Section 9.4.2.*

SPECIFIC COMMENT 7: Section 11.4, Worksheet #17: Sampling and Design Rationale, Reporting, Page 43: This section states “The QAPP Addendum activities will be documented in a Completion Report but does not describe the contents of the report or the estimated delivery turnaround time. Please revise this section to include a discussion of the contents of the Completion Report and expected delivery turnaround time.

RESPONSE TO SPECIFIC COMMENT 7: *Information that will be included in the Completion Report is noted throughout the QAPP Addendum. However, the text in Section 11.4 was revised to summarize the information to be included in the Completion Report. The delivery date for the Completion Report is already presented in the project schedule in Section 9.8.*

SPECIFIC COMMENT 8: Section 12, Worksheet #18: Sampling Locations and Methods, Page 44: The table in this section lists the analyte/analytical groups [i.e., Volatile Organic Compounds (VOCs), dissolved metals, anions]; however, the specific anions including nitrate, nitrite and sulfate which are listed in Worksheet #19 and 30, Sample Container, Preservation, and Hold Times are not listed as analytes in the table. Please revise Worksheet #18 to include the anions nitrate, nitrite and sulfate as analytes.

RESPONSE TO SPECIFIC COMMENT 8: *Worksheet #18 was not revised based on the comment. The specific analytes are appropriately listed in other worksheets in the QAPP Addendum, consistent with Uniform Federal Policy (UFP)-QAPP guidance.*

SPECIFIC COMMENT 9: Section 13, Worksheet #19 & 30: Sample Container, Preservation, and Hold Times, Page 45: The table in this section lists sample container, preservation, and hold times for nitrate, nitrite and sulfate, but does not include this information for VOCs in soil and VOCs and dissolved metals in groundwater that are listed in Worksheet #18, Sampling Locations and Methods. The table note states the sample container, preservation, and holding time for VOCs and dissolved metals are provided in Groundwater QAPP Revision 11 (Ahtna, 2023c); however, this information should be included in the current QAPP. Please revise Worksheets #19 and 30 to include sample container, preservation, and hold times for VOCs in soil and VOCs and dissolved metals in groundwater.

RESPONSE TO SPECIFIC COMMENT 9: *Worksheet #19 and 30 was not revised based on the comment. As stated in Section 1.0 of the QAPP Addendum, this QAPP is an addendum to Groundwater QAPP Revision 11 and applicable information from Groundwater QAPP Revision 11 is incorporated by reference.*

Attachment I:

Responses to Central Coast Regional Water Quality Control Board Comments on the Draft QAPP Addendum

Responses to Central Coast Regional Water Quality Control Board Comments on the Draft QAPP Addendum[1]

COMMENT 1: Section 3.0, Worksheet #3 & 5: Project Organization and QAPP Addendum Distribution – Please update this worksheet to list Karyn Steckling as the new Central Coast Water Board project manager.

RESPONSE TO COMMENT 1: *Worksheet #3 & 5 was revised per the comment.*

COMMENT 2: Section 9.2, Field Activities – We recommend relocating the following information to Section 9.2.1 “Borehole Drilling and Logging” from Section 9.2.2 “Well Construction”:

> *Extraction well EW-OU2-13-180 will be installed within the Upper 180-Foot Aquifer using a truck mounted mud rotary, sonic, or air rotary casing hammer drill rig. Regardless of the drilling method, continuous sampling will be performed when the borehole is within the expected depth range of the screen interval (approximately 185 to 225 feet bgs).*

RESPONSE TO COMMENT 2: *The text was revised per the comment.*

COMMENT 3: Section 9.2.2, Well Construction – Please revise this section to include additional details regarding the proposed construction well construction consistent with what is provided in Table 1 and Attachment C, Drawing CU6. Within the text of this section, please include the proposed borehole depth, proposed well casing depth, screen interval depths, and sump length. Additionally, Table 1 states that the sump will be five feet long, but Drawing CU6 defaults the sump length to two feet long; please provide consistency between all sections and consider revising Note 11 in Drawing CU6 to state that the sump is proposed to be five feet long.

RESPONSE TO COMMENT 3: *Section 9.2.2 was not revised based on the comment. The information requested in the comment is provided in other sections of the text and incorporated by reference in this section to Table 1 and Drawing CU6. Additional details regarding the proposed well construction in the text would be unnecessarily redundant. Table 1 was revised to reflect that the sump will be two feet long. The text, table, and attachments were checked for consistency per the comment.*

COMMENT 4: Section 9.2.3, Well Construction Materials and Table 1, Extraction Well Materials and Construction

a. Sump Construction: We recommend that you construct the bottom cap/sump out of stainless steel, not PVC. In Central Coast Water Board staff's experience, PVC bottom caps/sumps can be problematic when paired with stainless steel well screens; there have been instances where the PVC bottom failed due to the weight of the drill string during installation, and/or didn't hold up to post installation well development tooling that hit the well bottom, resulting in the need to re-drill/install the well with a stainless steel sump.

RESPONSE TO COMMENT 4a: *Table 1 was revised per the recommendation to reflect that the sump will be constructed with stainless steel.*

[1] In a letter dated March 8, 2024 (see Administrative Record No. BW-2948.3). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.

b. Piezometer Construction: In Section 9.2.3, Ahtna states, "Casing for the proposed well and the piezometric tube will consist of flush-joint, threaded, Schedule 80 PVC manufactured per ASTM International F480. The specific casing diameter is included in Table 1 and Attachment C, Drawing No. CU6." Also, Athna states, "The piezometric tube screen will consist of a new Schedule 80 PVC with a slot size of 0.020 inch." However, in Table 1, the piezometer casing type, screen type, and sump are all listed as constructed with Schedule 40 PVC. Please revise this section and table to consistently state the proposed piezometer casing material.

RESPONSE TO COMMENT 4b: *Table 1 was revised to reflect that the piezometer casing, screen, and sump will be constructed with Schedule 80 PVC.*

COMMENT 5: Section 9.2.3, Well Construction Materials – We agree that the centralizers used should be constructed out of stainless steel and not plastic, as Central Coast Water Board staff have learned that some plastic centralizers may contain per- and polyfluoroalkyl substances (PFAS).

RESPONSE TO COMMENT 5: *Comment acknowledged.*

COMMENT 6: Figures 2, 3, and 4 – Please revise these figures to include clear schematic cross sections of the hydrostratigraphy as the current figure inserts are blurred/pixelated.

RESPONSE TO COMMENT 6: *The figures were revised to include an inset of the schematic cross section with higher resolution.*

COMMENT 7: Figures 2 and 3 – Please revise these figures to include street names to match Figure 4 and as revised in Figures 2 and 3 in the *Final OUCTP Upper 180-Foot Aquifer Remedial Design Addendum*[2].

RESPONSE TO COMMENT 7: *The figures were revised per the comment.*

COMMENT 8: Figures 5 and 6 – Please aim to provide clearer base cross-section images in these figures so they are less blurry. Additionally, in Figure 5, either revise or explain what the black shape is that is shown on MW-OU-66-180L at approximately -100 feet elevation. Lastly, please consider revising the cross-sections in these figures to display the groundwater levels for the three different aquifers.

RESPONSE TO COMMENT 8: *The figures were revised to include cross sections with higher resolution. The black shape on Figure 5 was an error and was removed. As stated in Section 6.1.4, the cross sections were constructed to assist in the evaluation of lithology on flow within Operable Unit Carbon Tetrachloride Plume (OUCTP), specifically between the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer, which are fully saturated in the area shown on the figures. Therefore, depicting groundwater levels on the figures is not necessary for this evaluation and would distract from the primary purpose of the figures.*

[2] Final OUCTP Upper 180-Foot Aquifer Remedial Design Addendum: https://geotracker.waterboards.ca.gov/?surl=pjui8